DECEMBER • 1947

VOLUME XIX NUMBER 3

the Petroleum Engineer

ds for Operating Men

MEETINGS

Jan. 5—Nomads, New York Chapter, Louis Sherry's, 50th Street and Park Avenue.
Jan. 12—Nomads, Houston Chapter, The Houston Club, Houston, Texas.
Jan. 12-16, 1948—SAE, annual meeting, Book Cadillac Hotel, Detroit, Mich.
Jan. 14—Nomads, Los Angeles Chapter, Jonathan Club, Los Angeles, Calif.
Jan. 14-15—AAPG, regional meeting, Jefferson Hotel, St. Louis, Mo.
Feb. 2—Nomads, New York Chapter, Louis Sherry's, 50th Street and Park Avenue.
Feb. 11—Institute of Petroleum, Mason House, 26, Portland Place, London, W. I.
Feb. 15-19—AIME, annual meeting, Pennsylvania Hotel, New York.
Feb. 15-19—AIChE, regional meeting. New Orleans, Louisiana.
Mar. 1-5—ASTM, spring meeting, Hotel Statler, Washington, D. C.
Mar. 10—Institute of Petroleum, Manson House, 26, Portland Place, London, W. I.
Mar. 12-14—Texas Independent Producers & Royalty Owners Assn, Corpus Christi.
Mar. 24-26—NGAA, annual meeting, Texas Hotel, Fort Worth, Texas.
Mar. 24-26—Southern Gas Assn, annual meeting, Galveston, Texas.
Mar. 24-26—API, Mid-Continent district, production, Broadview Hotel, Wichita, Kans.
Mar. 24-26—Southern Gas Assn, annual meeting, Galveston, Texas.
Apr. 5-7—Western Petroleum Refiners Assn, annual meeting, Galvez and Buccaneer Hotels, Galveston, Texas.
Apr. 5-8—Natl Assn Corrosion Engineers, annual meet, Jefferson Hotel, St. Louis, Mo.
Apr. 5-8—Oil-Heat Institute of America, meeting & exposition, Coliseum, Chicago.
Apr. 13-15—Southern Gas Measurement Short Course, Univ. of Okla., Norman.
Apr. 14—Institute of Petroleum, Manson House, 26, Portland Place, London, W. I.
Apr. 14-15—API, Southwestern production division, Plaza Hotel, San Antonio, Texas.
Apr. 19-21—American Society of Lubricating Engineers, annual convention, Statler Hotel, Buffalo, N. Y.
Apr. 19-23—American Chemical Society, 113th national meeting, Chicago, Ill.
Apr. 21-23—National Petroleum Assn, Hotel Cleveland, Cleveland, Ohio.
Apr. 26-29—Am. Assn of Petroleum Geologists, Soc. of Economic Paleontologists & Mineralologists, & Soc. of Exploration Geophysicists, annual meeting, Denver, Colo.
Apr. 28-30—Liquefied Petroleum Gas Assn, annual convention, Kansas City, Mo.
May 4-5—AGA, National Gas Department, Spring meeting, Rice Hotel, Houston, Texas.
May 6-7—API, Pacific coast production division, Biltmore Hotel, Los Angeles.
May 12—Institute of Petroleum, Manson House, 26, Portland Place, London, W. I.
May 15-22—International Petroleum Exposition, Tulsa, Okla.
May 31—Gas Technology Short Course, Texas A & I College, Kingsville.

DRILLING AND PRODUCTION

Economics of Alaskan Exploration—K. Marshall Fagin 57
Application of Internal-Combustion Engine Power to Rotary Drilling Rigs—W. S. Crake 70
Design and Construction of Compressor Plants—Paul D. Torrey 108
New Acidizing Equipment Designed for Portability 134
Automatic Drilling Control—Martin E. True and R. R. Crockston 136
Corrosion of Oil Well Equipment—L. C. Case 150

REFINING AND NATURAL GASOLINE MANUFACTURE

Hydrocarbon Absorption and Fractionation Process Design Methods (Part 8)—Wayne C. Edmister 83
Insulating Refinery Equipment—John C. Albright 128
Ohio Launches Refinery Expansion Program—R. E. Luton 161

OIL AND GAS TRANSPORTATION

Self-Propelled Motorized Equipment Features Construction of Products Line—Frank H. Love 53
Automatic Control of Portland-Montreal Line—C. D. Batchelder and R. A. Rockwell 94

GENERAL

Postwar Progress in the Iranian Oil Fields 47
Flow Calorimeter Measures Specific Heat of Gases 148
New Thermometric Standard 158

REGULAR FEATURES

The Course of Oil 12
Scanning Washington's Oil Horizon 14
National Petroleum Situation 16
Highlights in Oildom 18
Current Oilfield Operations 20
Pipeline Developments 22
Refining and Natural Gasoline Activities 24
Machinery and Equipment 167
Trade Literature 178
Crude, Cracked and Volatile 188
Running Tour With Men in the Industry 190
The Petroleum Engineer's Continuous Tables (Installment No. 126) 199
Pacific Personalities 226
Book Reviews 229

THE PETROLEUM ENGINEER PUBLISHING COMPANY
Irwin-Keasler Building, Dallas 1, Texas **Phone:Central-4571**

EXECUTIVE—W. L. LOVE, *president.* W. T. BRYAN, *general manager and treasurer.*
EDITORIAL—K. C. SCLATER, *vice president and editor.*
FRANK H. LOVE, *managing editor* ERNESTINE ADAMS, *associate editor*
K. MARSHALL FAGIN, *field editor* REMY LAWSON, *editorial assistant*
RICHARD SNEDDON, *Pacific coast editor,* 653 West Glenoaks, Glendale 2, Calif., Citrus 2-8446.
ADVERTISING—T. J. CROWLEY, *vice president and advertising manager.*
New York—JOE B. WOODS, 52 Vanderbilt Avenue, New York 17, N. Y., MUrray Hill 4-1880.
Chicago—E. V. PERKINS, 22 West Maple Street, Chicago 10, Illinois, SUperior 1823.
Los Angeles—RICHARD P. McKEY, 2024 West Sixth Street, Los Angeles 5, FAirfax 1127.
CIRCULATION—C. R. BARRETT, *circulation manager.*
Copyright 1947 by The Petroleum Engineer Publishing Company
Articles in The Petroleum Engineer are indexed by Industrial Arts Index
A. B. C. **SUBSCRIPTION: 1 year, $2 — 2 years, $3** A. B. P.

DECEMBER • 1947

VOLUME XIX NUMBER 3

the Petroleum Engineer

ds for Operating Men

MEETINGS

Jan. 5—Nomads, New York Chapter, Louis Sherry's, 50th Street and Park Avenue.
Jan. 12—Nomads, Houston Chapter, The Houston Club, Houston, Texas.
Jan. 12-16, 1948—SAE, annual meeting, Book Cadillac Hotel, Detroit, Mich.
Jan. 14—Nomads, Los Angeles Chapter, Jonathan Club, Los Angeles, Calif.
Jan. 14-15—AAPG, regional meeting, Jefferson Hotel, St. Louis, Mo.
Feb. 2—Nomads, New York Chapter, Louis Sherry's, 50th Street and Park Avenue.
Feb. 11—Institute of Petroleum, Mason House, 26, Portland Place, London, W. I.
Feb. 15-19—AIME, annual meeting, Pennsylvania Hotel, New York.
Feb. 15-19—AIChE, regional meeting. New Orleans, Louisiana.
Mar. 1-5—ASTM, spring meeting, Hotel Statler, Washington, D. C.
Mar. 10—Institute of Petroleum, Manson House, 26, Portland Place, London, W. I.
Mar. 12-14—Texas Independent Producers & Royalty Owners Assn, Corpus Christi.
Mar. 24-26—NGAA, annual meeting, Texas Hotel, Fort Worth, Texas.
Mar. 24-26—Southern Gas Assn, annual meeting, Galveston, Texas.
Mar. 24-26—API, Mid-Continent district, production, Broadview Hotel, Wichita, Kans.
Mar. 24-26—Southern Gas Assn, annual meeting, Galveston, Texas.
Apr. 5-7—Western Petroleum Refiners Assn, annual meeting, Galvez and Buccaneer Hotels, Galveston, Texas.
Apr. 5-8—Natl Assn Corrosion Engineers, annual meet, Jefferson Hotel, St. Louis, Mo.
Apr. 5-8—Oil-Heat Institute of America, meeting & exposition, Coliseum, Chicago.
Apr. 13-15—Southern Gas Measurement Short Course, Univ. of Okla., Norman.
Apr. 14—Institute of Petroleum, Manson House, 26, Portland Place, London, W. I.
Apr. 14-15—API, Southwestern production division, Plaza Hotel, San Antonio, Texas.
Apr. 19-21—American Society of Lubricating Engineers, annual convention, Statler Hotel, Buffalo, N. Y.
Apr. 19-23—American Chemical Society, 113th national meeting, Chicago, Ill.
Apr. 21-23—National Petroleum Assn, Hotel Cleveland, Cleveland, Ohio.
Apr. 26-29—Am. Assn of Petroleum Geologists, Soc. of Economic Paleontologists & Mineralologists, & Soc. of Exploration Geophysicists, annual meeting, Denver, Colo.
Apr. 28-30—Liquefied Petroleum Gas Assn, annual convention, Kansas City, Mo.
May 4-5—AGA, National Gas Department, Spring meeting, Rice Hotel, Houston, Texas.
May 6-7—API, Pacific coast production division, Biltmore Hotel, Los Angeles.
May 12—Institute of Petroleum, Manson House, 26, Portland Place, London, W. I.
May 15-22—International Petroleum Exposition, Tulsa, Okla.
May 31—Gas Technology Short Course, Texas A & I College, Kingsville.

DRILLING AND PRODUCTION

Economics of Alaskan Exploration—K. Marshall Fagin 57
Application of Internal-Combustion Engine Power to Rotary Drilling Rigs—W. S. Crake 70
Design and Construction of Compressor Plants—Paul D. Torrey 108
New Acidizing Equipment Designed for Portability 134
Automatic Drilling Control—Martin E. True and R. R. Crockston 136
Corrosion of Oil Well Equipment—L. C. Case 150

REFINING AND NATURAL GASOLINE MANUFACTURE

Hydrocarbon Absorption and Fractionation Process Design Methods (Part 8)—Wayne C. Edmister 83
Insulating Refinery Equipment—John C. Albright 128
Ohio Launches Refinery Expansion Program—R. E. Luton 161

OIL AND GAS TRANSPORTATION

Self-Propelled Motorized Equipment Features Construction of Products Line—Frank H. Love 53
Automatic Control of Portland-Montreal Line—C. D. Batchelder and R. A. Rockwell 94

GENERAL

Postwar Progress in the Iranian Oil Fields 47
Flow Calorimeter Measures Specific Heat of Gases 148
New Thermometric Standard 158

REGULAR FEATURES

The Course of Oil 12
Scanning Washington's Oil Horizon 14
National Petroleum Situation 16
Highlights in Oildom 18
Current Oilfield Operations 20
Pipeline Developments 22
Refining and Natural Gasoline Activities 24
Machinery and Equipment 167
Trade Literature 178
Crude, Cracked and Volatile 188
Running Tour With Men in the Industry 190
The Petroleum Engineer's Continuous Tables (Installment No. 126) 199
Pacific Personalities 226
Book Reviews 229

THE PETROLEUM ENGINEER PUBLISHING COMPANY
Irwin-Keasler Building, Dallas 1, Texas **Phone:Central-4571**

EXECUTIVE—W. L. LOVE, *president.* W. T. BRYAN, *general manager and treasurer.*
EDITORIAL—K. C. SCLATER, *vice president and editor.*
FRANK H. LOVE, *managing editor* ERNESTINE ADAMS, *associate editor*
K. MARSHALL FAGIN, *field editor* REMY LAWSON, *editorial assistant*
RICHARD SNEDDON, *Pacific coast editor,* 653 West Glenoaks, Glendale 2, Calif., Citrus 2-8446.
ADVERTISING—T. J. CROWLEY, *vice president and advertising manager.*
New York—JOE B. WOODS, 52 Vanderbilt Avenue, New York 17, N. Y., MUrray Hill 4-1880.
Chicago—E. V. PERKINS, 22 West Maple Street, Chicago 10, Illinois, SUperior 1823.
Los Angeles—RICHARD P. McKEY, 2024 West Sixth Street, Los Angeles 5, FAirfax 1127.
CIRCULATION—C. R. BARRETT, *circulation manager.*
Copyright 1947 by The Petroleum Engineer Publishing Company
Articles in The Petroleum Engineer are indexed by Industrial Arts Index
A. B. C. **SUBSCRIPTION: 1 year, $2 — 2 years, $3** A. B. P.

Looking Around

By THE OBSERVER

THAT'S THE WAY THE MONEY GOES

Bills! Bills!! Bills!!!

Yes sirree, sir, our experience is just about like yours. We're in the same boat. We keep buying things—and the bills keep rolling in.

In a year's time they amount to $48,000,000. That's the latest figure we've added up from 160,000 purchases in a twelvemonth.

We buy rags (to keep your windshield clean, sir). And flowers. And anchors. And castor oil. And microscopes. And perfume (for fly-spray, madam). And things really too numerous to mention.

We buy Christmas trees that Santa Claus can recognize. And we buy "Christmas trees" that are mechanical gadgets to control the flow from an oil well. We buy all sorts of things.

There's no way to figure exactly how very many western firms benefit by this buying. But here's a suggestive sidelight. While considerable of our purchasing goes on, month after month, in a routine fashion, even in a slim year calls from salesmen run around 20,000.

The truest thing ever said about a corporation like ours is that it can never save a penny. Every cent it takes in always has a use—for payroll, taxes, purchases, dividends, reserve, etc., etc.

But, if we can sell to lots of people, we are only too happy to buy from lots of people. If that's the way our money goes, why, it's perfectly all right with us. For that, sir—that's the way the country grows.

STANDARD OF CALIFORNIA

TRANSPORTATION PROBLEM SERIOUS

As the year 1947 draws to a close, the oil industry finds itself confronted with problems. The principal one, not of the industry's own making, is a lack of adequate domestic transportation facilities. It is a serious problem—serious because it so vitally affects the public welfare. It is so serious that suggestions have been offered that attempts be made to keep the upper reaches of the Mississippi and Ohio rivers, which normally freeze over in winter, open to transportation beyond the normal winter period to the barge facilities available on those two rivers. The same suggestion has been made with respect to the Hudson River in New York State.

Construction of transportation facilities, as well as others for refining, production, and marketing divisions of the industry, are being delayed by shortages of essential materials such as casing and tubing of all kinds, line pipe, compressors, pumps, plates, structurals, castings, sheets, tin mill products, electrical equipment, valves and fittings, and high and low pressure tanks.

Shortages of these materials have made it impossible for the industry to proceed with scheduled expansion and modernization programs. It is estimated that lack of these materials has delayed construction programs anywhere from several months to two or three years.

INDUSTRY'S CONCERTED AID

One may ask what the oil industry is doing toward meeting not only present problems, but also anticipated future domestic demands for oil and its products, especially those affecting the public and national interest. To meet rising demands for its products the oil industry is making record capital investments of more than four billion dollars in the two-year period—1947-1948—to provide for new and expanded facilities throughout the United States.

It will drill this year an estimated 35,000 new oil wells, a new high record, including more than 5000 wells for exploratory purposes in the hope of finding additional new oil reserves. In the production division alone, the industry will make capital outlays estimated at more than two billion dollars in the two-year period.

It has plans underway for construction of refinery facilities having a capacity of about 450,000 barrels of crude daily, but the completion of these installations will take from six to twenty-four months from the start of work. There is a prospect that this figure will be augmented in the near future. Expenditures for refining facilities in the two years are estimated to exceed one billion one hundred million dollars.

It is building new pipe lines and increasing the capacity of old ones, as well as providing for other transportation equipment on which it will make an aggregate investment in 1947-1948 of approximately four hundred forty million dollars.

It is investing about four hundred eighty million dollars in expanding distribution and marketing facilities.

The industry has built the nation's proved crude oil reserve to a record high and is maintaining production of crude oil at high rates, consistent with sound conservation practices in an effort to assure the nation an adequate supply of products. Some of the operations are proving extremely costly.

It is operating some of its older, high cost refining capacity in addition to its modern, more efficient facilities to serve public, Army, Navy, and industrial demands, and some of these refineries are operating well above their listed capacities.

It is transporting crude oil and products into the Middle West by tank cars, which is a much more costly method than by pipeline and barge.

The oil industry is carrying on the most extensive operations in its history and is doing it without fanfare. In fact the public knows little—if anything of the industry's record breaking service.

PUBLIC CAN HELP

The consuming public can render material aid to the industry in stretching the available supplies and making the most of existing transportation facilities.

It can do so by driving in a more conservative manner and taking good care of automobiles, thus spreading gasoline supplies in each area and making it possible for all car owners to get what products they need.

It can fill, and keep filled, its fuel oil tanks for use at the peak of winter demand so that the industry can utilize its storage capacity at maximum to prevent a local exhaustion of supplies.

It can maintain moderate temperatures in homes during the coming heating season, thus spreading supplies so that no one suffers discomfort from lack of fuel oil.

It can check oil burners now in use, many of which are outmoded, if not obsolete, and are, therefore, consuming much more oil than they should. A careful check by competent heating engineers may lead to greatly increased efficiency in the burning of oil.

Geared TO OIL INDUSTRY

ENGINEERING principles are steadily replacing rule of thumb in oil field operations. Resulting improvements in methods and equipment in turn demand improved materials. Through continuing research in the laboratory and in the field, LONE STAR Cements are geared to Oil Industry progress, as demonstrated by outstanding field performance. Select the LONE STAR Cement that fits your job.

LONE STAR CEMENT CORPORATION

Offices: DALLAS • HOUSTON • NEW ORLEANS • KANSAS CITY, MO.
BIRMINGHAM • JACKSON, MISS. • INDIANAPOLIS • BOSTON
ALBANY, N. Y. • BETHLEHEM, PA. • CHICAGO • NORFOLK
PHILADELPHIA • ST. LOUIS • WASHINGTON, D. C. • NEW YORK

SCANNING WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON—Finishing touches are being applied to the Truman Administration's legislative program for implementing the Supreme Court's tidelands decision, including provisions for carving out "government oil reserves" from submerged lands off the Atlantic, Gulf, and Pacific coasts.

States righters in Congress are digging in for a fight that will decide the most important federal vs. state issue since 1865, believing that state and private property rights anywhere in the United States are endangered by the policy laid down by the Supreme Court.

The Trumanites, on the other hand, will strive to narrow the issue down to tidelands oil even to the point of arguing that only the oil companies will benefit from any legislative move to overturn the high court's ruling. Truman's program, they will contend, will "save" these oil lands, which are the "people's property."

The program will be sent up by the White House early in the coming year, timed to hit Capitol Hill when agitation over the oil shortage is reaching a crescendo. (Half a dozen congressional committees are now investigating the oil situation, ranging from probes of complaints from independent refiners and distributors or consumer complaints on lack of fuel oil or "too high" prices to the worldwide survey by the House Armed Forces Committee to determine the adequacy of military oil supplies.)

President Truman's personal views are well known. He has pledged that any legislation quitclaiming the tidelands to the states will be vetoed. Also, Truman was most emphatic several months ago when asked by a Democratic leader what he would do if Congress passed a quitclaim bill. Truman is supposed to have replied, vigorously, that he would veto it on the grounds that the tidelands oil belongs to all the people.

More recently, Truman's conservation speech dedicating the Everglades National Park contained some harsh language that has been interpreted by some in the Administration as referring to the tidelands situation. Truman urged an unceasing fight for conservation "to protect earlier victories," then went on to say, "There are always plenty of hogs who are trying to get our natural resources for their own personal benefit." In listing these resources, Truman included "our mineral reserves." Continuing, Truman said:

"We have to remain constantly vigilant to prevent raids by those who would selfishly exploit our common heritage for their own private gain. Such raids on our natural resources are not examples of enterprise and initiative. They are attempts to take from all the people just for the benefit of a few."

Such is the stage setting for Truman's attempt to bat down moves to return the tidelands to the states and put over instead a program for bottling up the most likely submerged oil lands as "government reserves."

There is another development that is bothering oil men here interested in the tidelands issue, although they can not be certain that it is part of the Truman strategy. It is the investigation of "oil lobbying," which appears aimed principally at any efforts the industry may be making toward encouraging the states in their fight for a quitclaim resolution. Indeed, it is rumored that Attorney General Tom Clark cited "tidelands lobbying" as one of the matters the Department of Justice officials should question oil executives and association leaders about. Some oil men, privately, suggest this is a move to intimidate the industry.

Meanwhile, the states are organizing to push through Congress an outright grant to the states of sovereignty and dominion over submerged lands, repudiating the Supreme Court's newly declared policy. They feel that something more than a quitclaim resolution will be needed.

Shrewd observers, such as Dean Terrill (Kerr-McGee) speaking at Denver recently, take small comfort from the Supreme Court's refusal to amend its tidelands decree to include "ownership" in describing federal rights. Indeed, this may make the situation more difficult. If it were only an issue of federal vs. state ownership of lands, then any congressman might be disposed to vote for the states. But some may hesitate when called upon to renounce on behalf of the United States this new kind of property rights, that the Supreme Court called "full dominion" in the tidelands decision.

But the states righters are not taking a defeatist attitude. Whatever the odds against them, they *must* win out in Congress or else the federal government may take over any state or property anywhere in the United States when some official finds there is a "paramount need" for it by the national government. That is their position and they are going to fight it out.

Meanwhile, top military leaders are taking a more active interest in the tidelands situation (perhaps because of trouble popping in the Middle East, which may be the reason also for their increased insistence lately on Latin American oil development).

Oil was listed as their No. 1 problem when the National Security Resources Board held its organization meeting recently. (NSRB is the top level advisory agency, reporting only to the President, which was set up in the new Army-Navy merger law.) This was not long in having effect.

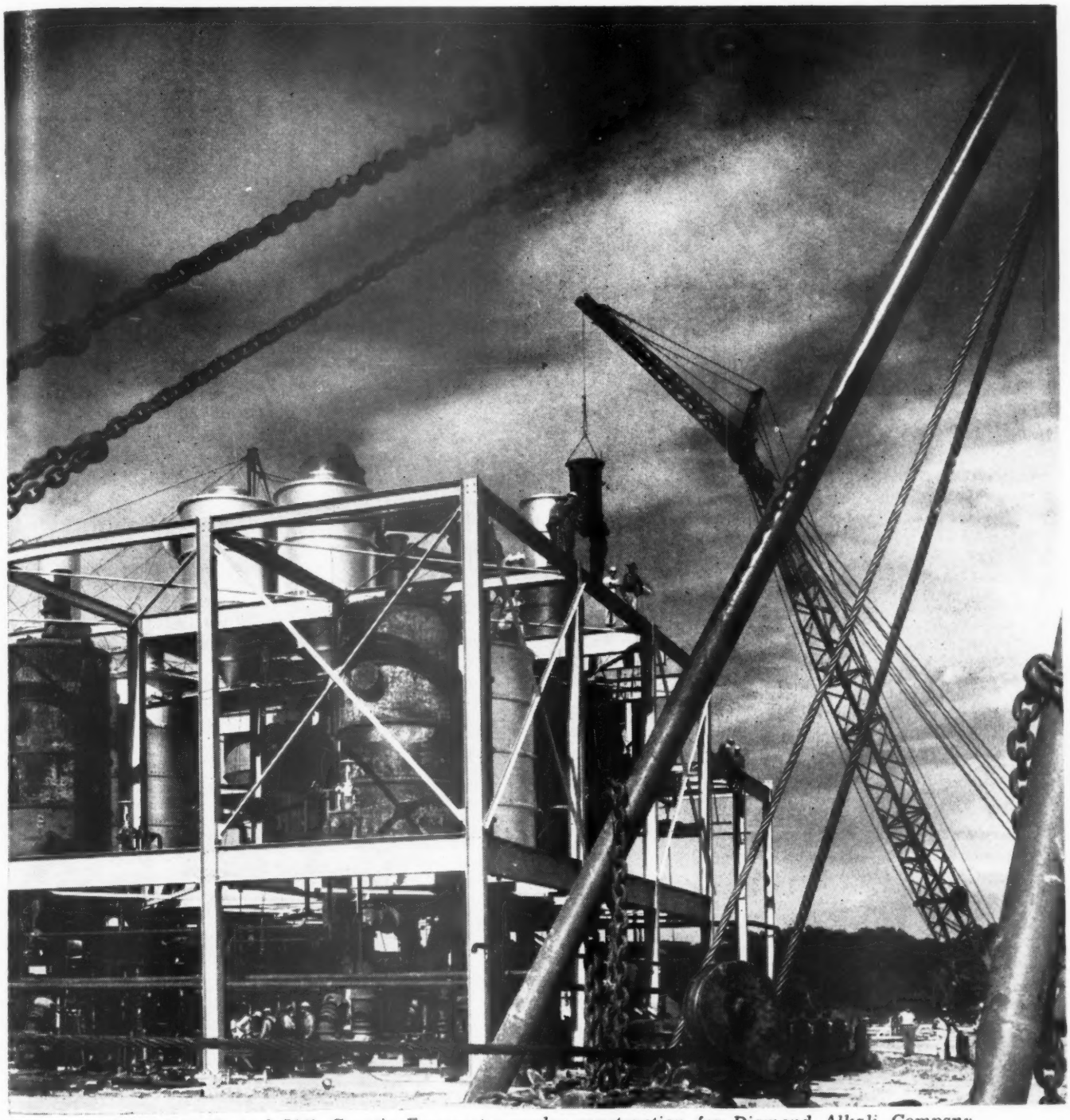
First version of the submerged lands leasing bill, drafted by Interior Department, provided that a Submerged Lands Commission be set up within Interior with policy-making powers as well as administrative. Later, this was objected to by the military who insisted, successfully, that NSRB should make the policies and hold veto power over Interior's administration of the proposed leasing law.

Key point in the submerged lands bill is the proposal that the President be given the power to declare—upon recommendation of NSRB—any submerged land area to be a "government oil reserve." Development of such areas would then be strictly regulated, according to policies laid down by NSRB.

Where the NSRB wanted an area containing valid state leases converted into a "government reserve," the operator would be bought out at a fixed price.

In areas where it was decided that the national interest permitted it, state lessees could exchange their leases for federal leases, subject to conditions imposed by the federal agency. New leases on areas opened up for prospecting would go to the highest bidder.

Another provision proposed by the military is that the government be given first call—in case of war or national emergency—on any oil or gas produced from a submerged lands lease. This probably will be in the bill as it goes to Congress. But a more drastic proposal may be held back—for the present, at least, namely, that none of the submerged areas be leased out until the government itself has a chance to survey the oil possibilities, including the drilling of test wells. If that proposal does go to Congress, it is in for a tough fight—as is the whole program for that matter.



Nickel-lined steel 50% Caustic Evaporator under construction for Diamond Alkali Company

The $12,000,000 Diamond Alkali Job

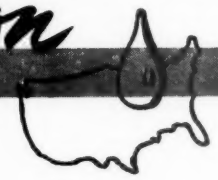
Chemical plants, such as the Houston Works of the Diamond Alkali Company, are a specialty of Brown & Root, Inc. We are engineering and erecting this vast and ultra-modern plant and will deliver it in production of caustic soda and chlorine. *Thanks to Industrial & Engineering Chemistry for this picture, which they used as a front cover illustration.*

BROWN & ROOT, Inc.

P. O. Box 2634

Houston, Texas

national petroleum situation



By H. J. STRUTH,*
Petroleum Economist

PRICE RELATIONSHIP. If the "hold the price line" policy could not be maintained for crude oil it could not be maintained for refined products without penalizing a large group of refiners. The 50-cent crude advance was not out of line—crude values are still under the all-commodity index relative to 1936—but refiners' margins must be adjusted through relatively higher prices for products. Higher prices for gasoline and distillate fuels, which are economically justified, offer an effective means of curbing the domestic demand for these products.

*Editor, *The Petroleum Data Book.*

DEMAND OUTLOOK. Preliminary figures for 1947 indicate demand for all oils of 5,822,000 bbl daily, against a total supply, including imports, of 5,845,000 bbl. The margin above demand is about 23,000 bbl daily. Projected demand next year may exceed 6,100,000 bbl daily, but total supply is expected to exceed demand by at least 23,000 bbl daily and may provide a surplus above requirements of as much as 55,000 bbl daily. Despite the unprecedented demand, the outlook presents nothing to support shortage talk so frequently emanating from Washington.

RISING DOMESTIC SUPPLY. Ability of the oil industry to meet requirements is shown by the astounding rise in domestic supplies since war's end. Since 1945 U. S. production of crude oil and natural gasoline have increased 641,000 bbl daily. Projections through 1948 anticipate further gains that will extend the increase in supply over 1945 to at least 800,000 bbl. This, together with an increase in imports of 200,000 bbl, spells an increased supply of 1,000,000 bbl daily. Projected demand, including exports, for 1948 will be about 850,000 bbl a day greater than the last war year, 1945.

41,000 WELLS IN 1948. Next year will no doubt be the banner year in the search for new oil fields. Higher crude prices are expected to provide the impetus and total completions are likely to exceed 41,000—an all-time peak. Well completions this year will total about 34,370. Wildcats may top 6200 next year, against 5100 this year. More steel will be the top order of the day in 1948.

Comparative Statistics, November, 1947

*All figures are computed on a Bureau of Mines' Basis**

	Nov. 1947(p)	October 1947(p)	Nov. 1946	This year to date	Last year to date	Per cent change
Wells drilling	4,600	¶4,650	4,100	4,600	4,100	+12
Total wells drilled§	3,056	3,249	2,597	31,130	27,073	+15
Development wells	2,581	2,760	2,162	26,452	22,915	+15
Oil	1,527	1,693	1,230	16,227	13,536	+20
Gas	280	317	309	3,031	2,819	+ 8
Dry§	774	750	623	7,194	6,560	+10
Per cent dry	30.0	27.2	28.8	27.2	28.6	— 1.4
Wildcat wells	475	489	435	4,678	4,158	+13
Oil	66	72	45	711	591	+20
Gas	18	22	14	200	121	+65
Dry	391	395	376	3,767	3,446	+ 9
Per cent dry	82.3	80.8	86.4	80.5	82.9	— 2.4
Crude supply•	167,000	¶172,050	151,526	1,779,336	1,665,958	+ 7
Daily average	5,567	5,550	5,051	5,327	4,988	
Crude demand‡	167,460	172,200	147,398	1,779,670	1,657,429	+ 7
Daily average	5,582	5,555	4,913	5,328	4,962	
Crude stocks	230,140	230,600	231,788	230,140	231,788	— 1
Days supply	41	42	47	41	47	
Natural gasoline production	11,000	11,200	10,005	118,357	104,652	+13
Daily average	367	361	334	354	313	
Motor fuel production	72,330	75,600	66,072	764,359	707,026	+ 8
Daily average	2,411	2,419	2,202	2,289	2,117	
Gasoline yield, per cent	40.5	40.7	41.7	40.1	39.5	+ 0.6
Motor fuel demand‡	69,280	75,400	64,545	771,104	715,241	+ 8
Daily average	2,309	2,432	2,152	2,309	2,141	
Motor fuel stocks△	83,500	80,450	85,467	83,500	85,467	— 2
Days supply	36	33	40	36	40	
Fuel oil production	64,150	67,000	56,756	686,877	658,353	+ 4
Daily average	2,138	2,161	1,892	2,057	1,971	
Fuel oil demand‡	70,050	68,200	65,998	754,879	676,568	+12
Daily average	2,335	2,200	2,200	2,260	2,026	
Fuel oil stocks	113,750	115,800	120,880	113,750	120,880	— 6
Days supply	49	53	55	49	55	
Refinery still runs	158,300	163,300	140,514	1,686,415	1,582,026	+ 7
Daily average	5,277	5,268	4,684	5,049	4,737	
All refined stocks	288,400	287,300	291,254	288,400	291,254	— 1
Days supply	50	50	54	50	54	

Economic Position of U. S. Petroleum Industry

Eleven Months Ending November 30, 1947

	Normal	Actual	Per cent of normal
Drilling*** (wells completed)	28,390	29,063	102
Production (daily crude output)	5,075	5,058	100
Refining (daily still runs)	5,065	5,049	100
Stocks (crude and refined)	524,000	518,540	99
Price of crude (per bbl)	$1.88**	$2.59	138†

Current Crude Oil Prices

Reflecting general price increase of Dec. 6

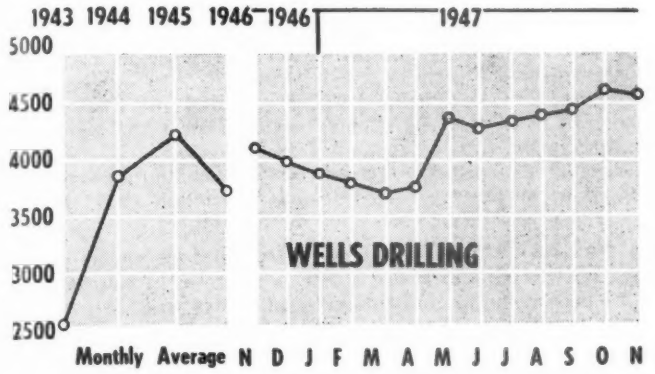
U. S. average	$2.59	Louisiana	$2.62	**Basic crude prices:**	
Texas	2.61	Arkansas	2.43	Oklahoma-Kansas (36 gr.)	$2.57
California	2.32	New Mexico	2.40	Texas Gulf Coast (36 gr.)	2.80
Oklahoma	2.63	Mississippi	2.42	East Texas	2.65
Kansas	2.62	Illinois	2.76	West Texas (36 gr.)	2.44
		Other states	3.15	California Signal Hill (26 gr.)	2.31
				Pennsylvania, Bradford	5.00

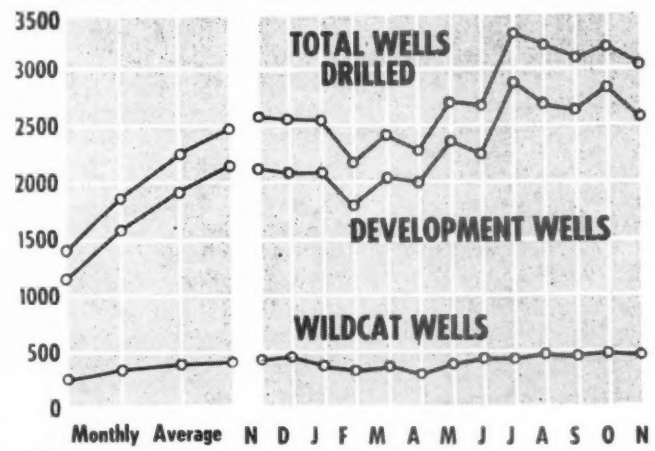
Drilling and Production Statistics by States

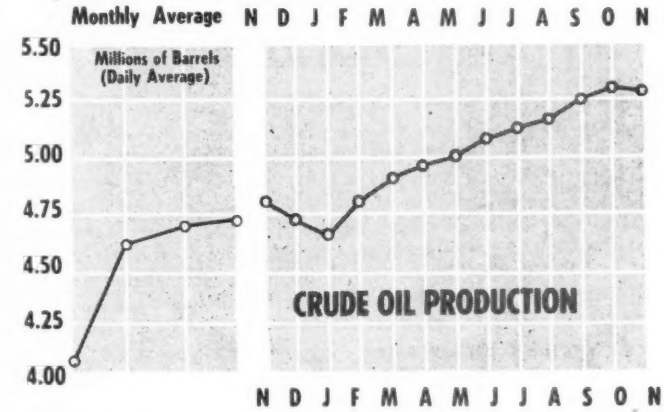
	Nov. 1947(p)	October 1947(p)	Nov. 1946	This year to date	Last year to date	Per cent change
Total wells drilled§	3,056	3,249	2,597	31,130	27,073	+ 15
Texas	828	835	615	8,729	7,223	+ 21
California	179	211	175	1,867	1,662	+ 12
Oklahoma	299	346	374	3,827	2,786	+ 37
Kansas	250	294	187	2,495	1,852	+ 35
Louisiana	180	189	143	1,528	1,297	+ 18
Arkansas	41	45	17	316	169	+ 87
New Mexico	44	44	31	506	364	+ 39
Mississippi	35	48	28	451	226	+100
Illinois	182	200	189	1,903	2,167	— 12
Other states	1,018	1,037	838	9,508	9,327	+ 2
Wildcats drilled	475	489	435	4,678	4,158	+ 13
Texas	191	180	132	1,701	1,530	+ 11
California	23	34	24	311	227	+ 37
Oklahoma	68	75	84	777	505	+ 54
Kansas	32	40	45	368	284	+ 30
Louisiana	31	25	21	267	231	+ 16
Arkansas	7	9	5	65	38	+ 71
New Mexico	5	5	3	45	41	+ 10
Mississippi	7	9	8	87	68	+ 28
Illinois	29	34	56	379	559	— 32
Other states	82	78	57	678	675	0
Daily crude production	5,284	5,289	4,823	5,058	4,751	+ 6
Texas	2,351	2,387	2,123	2,233	2,089	+ 7
California	920	916	871	910	862	+ 6
Oklahoma	405	398	361	384	370	+ 4
Kansas	295	298	273	288	266	+ 8
Louisiana	465	457	414	436	391	+ 12
Arkansas	84	83	79	82	78	+ 5
New Mexico	124	121	103	112	101	+ 11
Mississippi	109	104	80	95	65	+ 46
Illinois	179	174	200	182	207	— 12
Other states	352	351	319	336	322	+ 4

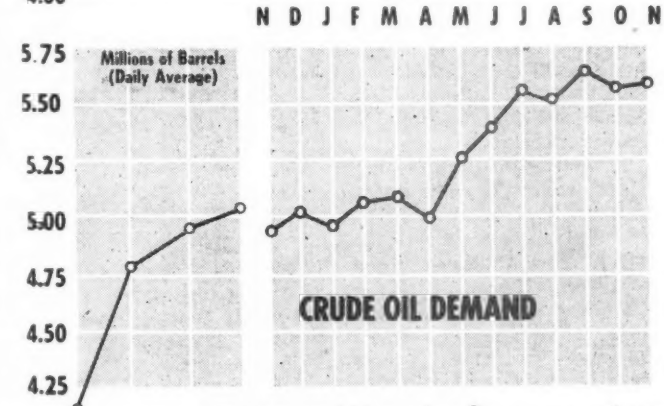
*Unless otherwise stated all figures represent thousands of barrels. ***Does not include input wells. (p) Preliminary. •Includes domestic production and imports. †Total demand, including exports. **Price 1926 (Index 100). △Includes finished and natural gasoline. §Includes service wells. †All Commodity Index: 159. ¶Revised.

Preliminary estimates based upon data furnished by American Petroleum Institute, U. S. Bureau of Mines, State Agencies, and other official sources.

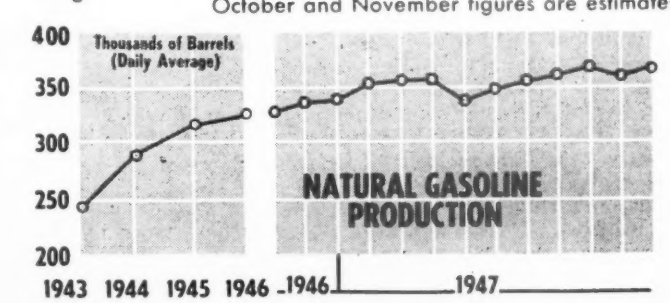


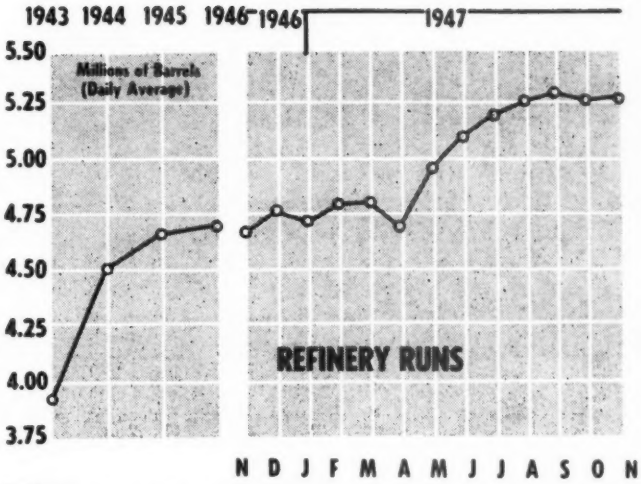


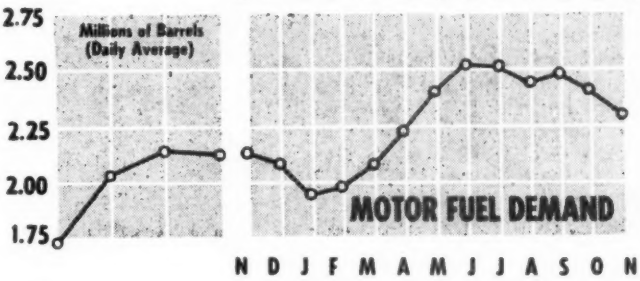


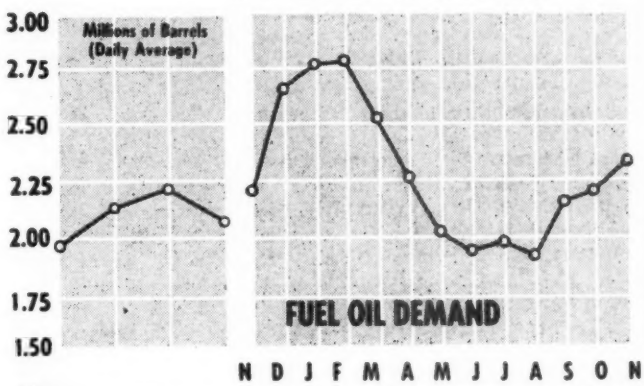


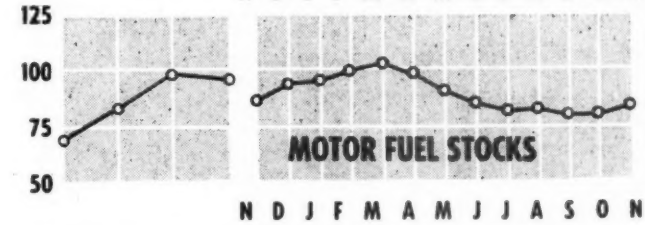
October and November figures are estimates.

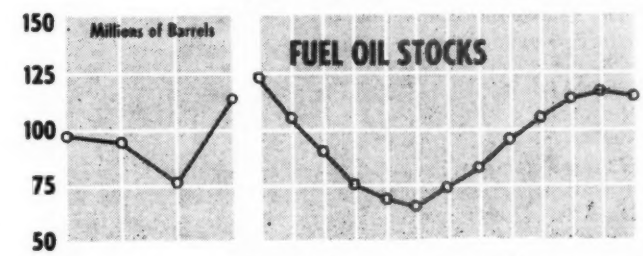




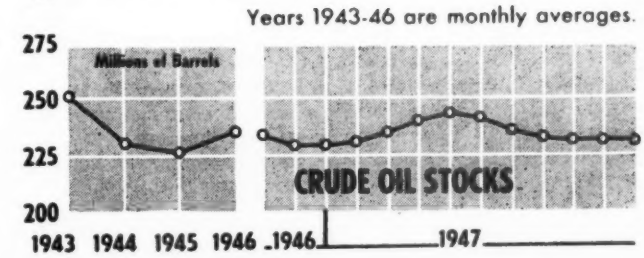




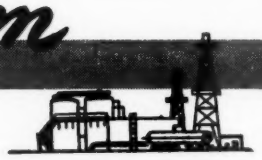




Years 1943-46 are monthly averages.



highlights in oildom



● **CRUDE PRICE INCREASE GENERAL.** Sun Oil Company's November 28 posting of a 50 cents per bbl increase in crude oil prices has become a general trend throughout the industry. Sun officials said the move was made to hold its source of supply in the face of prevailing bonuses and premiums offered by other buyers.

A few days later the Union Oil Company of California raised prices on the west coast an average of 40 cents a bbl.

On December 5, Magnolia Petroleum Company and other affiliates of the Socony-Vacuum Oil Company, Inc., increased crude prices 50 cents a bbl effective December 6. The Sinclair group of companies immediately met this increase.

As a result of these postings the higher price was extended to the Mid-Continent, Gulf Coast, Rocky Mountain, and Illinois Basin areas.

The following day (December 6) Sinclair Refining extended its price to Pennsylvania Grade fields and immediately it was met by four other purchasers, bringing that grade of oil to $5.00 a bbl.

On December 6 the increased price was met by Phillips Petroleum Company, Aetna Refining, Ashland Oil and Refining Company, Bell Oil and Gas, Ben Franklin Refining, Pure Oil Company (in Oklahoma and Kansas only), Sohio Petroleum Company, and Southern Minerals Corporation (Texas only).

On Monday, December 8, the movement was joined by Humble Oil and Refining Company, The Texas Company, Gulf, Shell, Pan American, and Stanolind, as well as numerous smaller companies. The price advance of these companies was retroactive to 7 a.m. of the previous Saturday (December 6).

● **NEW SHELL LABORATORY.** One of the nation's largest and most modernly equipped research laboratories devoted to improvement in methods of discovery and production of oil, recently completed in Houston, Texas, by the Shell Oil Company, Inc., was dedicated December 5.

The new Exploration and Production Laboratory will increase Shell's research activities in this field. H. S. M. Burns, president, explained, and will centralize functions that were formerly carried on in widely scattered localities.

The three-story building provides 40,000 sq ft for research on the first two floors, about 8000 more for service and accessory machinery on the third. Besides fully equipped, air-conditioned research rooms, the building includes machine shops, conference rooms, a cafeteria, and a library with shelves for 10,000 volumes.

The laboratory operates on the theory that problems in exploration for and production of crude oil are so closely related that research in one field cannot proceed independently of research in the other. Accordingly, the staff is divided into physical, chemical, and geological departments, each of which handles the appropriate phase of every problem the laboratory attempts to solve.

The dedication ceremonies were held at 3 p.m. in the laboratory building on Bellaire Boulevard, Houston. Principal speakers were Burns, Dr. Harold Gershinowitz, laboratory director, and Colonel E. O. Thompson, chairman of the Texas Railroad Commission. Shell officials conducted tours of the laboratory for local business leaders, university professors, and press representatives. A reception for guests followed the dedication.

● **TIDELANDS RESOLUTION TO CONGRESS.** Rep. Charles K. Fletcher of California has introduced a joint resolution under which the Federal Government would surrender its claims to tidelands.

The resolution is identical with one offered in the Senate by Sen. E. H. Moore of Oklahoma, Sen. William F. Knowland of California and Pat McCarran of Nevada.

Senator Moore said hearings before his Senate judiciary subcommittee on the proposed tidelands legislation would be delayed until early next year.

● **GAS ACT DELAYED.** Rep. Ross Rizley of Oklahoma stated recently that all efforts to get Senate approval of Natural Gas Act amendments would be delayed until next year. The amendments would define and restrict Federal Power Commission authority to regulate interstate movement of natural gas. The bill passed the House last session, but did not get out of the Senate commerce committee.

● **VENEZUELA OIL FOR TEXAS CITY.** The awarding of a contract for 19,200,000 bbl of royalty oil to the Petrol Terminal Corporation by the Venezuelan ministry of development has been reported. The oil will be delivered over a two-year period beginning in February, 1948.

The Petrol Terminal Corporation purchased a refinery at Texas City from the WAA. It is part of the old Southport plant.

The awarding of the contract to Petrol brings the total sales of Venezuelan royalty oil to date to about 26,500,000 bbl. Reports say this oil is bringing premiums of 15 cents a bbl.

● **ASK BAN ON OIL EXPORTS.** Sen. Hugh Butler of Nebraska and Rep. Richard Welch of California have asked President Truman to prohibit the export of oil and oil products to foreign countries "with the possible exception of the Philippine Islands."

As chairmen of the Senate and House committees on public lands, they wrote Mr. Truman that they "are very much concerned over the shipment of irreplacable oil and oil products" to foreign countries.

"We respectfully and urgently request that you issue the necessary instructions to place a prohibition on the exportation of oil and oil products to foreign countries," they wrote.

They said that the nation is now drawing on its approximately 20,000,000,000-bbl reserve at a yearly rate of 1,750,000,000 bbl.

"We have been informed by the Department of Commerce that the United States is exporting oil and oil products at the rate of 140,000,000 bbl a year. If this exportation is stopped, it will bring just that much relief to our domestic situation," they added.

● **GOVERNOR JESTER HEADS COMPACT.** Gov. Beauford H. Jester of Texas was elected chairman of the Interstate Oil Compact Commission at the closing day's session in Oklahoma City. He succeeds Hiram M. Dow of Roswell, New Mexico. Other officers are: E. Leland Richardson, Baton Rouge, Louisiana, first vice chairman; Don T. Andrus, Bradford, Pennsylvania, second vice chairman, and Earl Foster, Oklahoma City, executive secretary.

The commission, in a resolution, reiterated its position in the tidelands matter, drawing attention to an address of Gov. Dwight Green of Illinois at an earlier session of the commission. Green urged the member states to press for congressional action to return to the states the sovereign rights that were taken away in the California case.

"It seems to me that the governors of the states which have ratified the oil compact have a particular responsibility to rally their people and their representatives in congress to the very serious issues raised by the tidelands decision," he said. "I believe it is clearly the duty of congress speedily to take such action as will nullify the effect of the decision."

Unitization and unit operation of oil fields were discussed in a series of papers at the closing session. R. M. Williams, Phillips Petroleum attorney from Bartlesville, reviewed legal aspects and discussed in detail some of the problems encountered in the West Edmond and West Cement cases in Oklahoma. Paul Montgomery, consulting geologist of Lafayette, Louisiana, discussed technical phases of unit operation in several Louisiana fields.

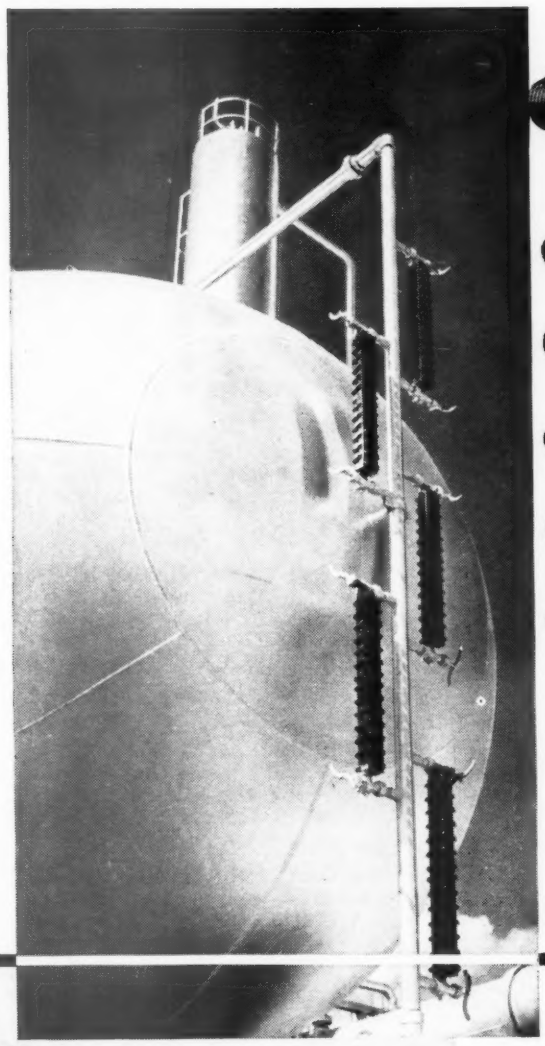
Opening the three-day session December 4, a commemorative plaque for the discovery well of the Oklahoma City field was presented to the Cities Service Oil Company by the Mid-Continent Oil and Gas Association.

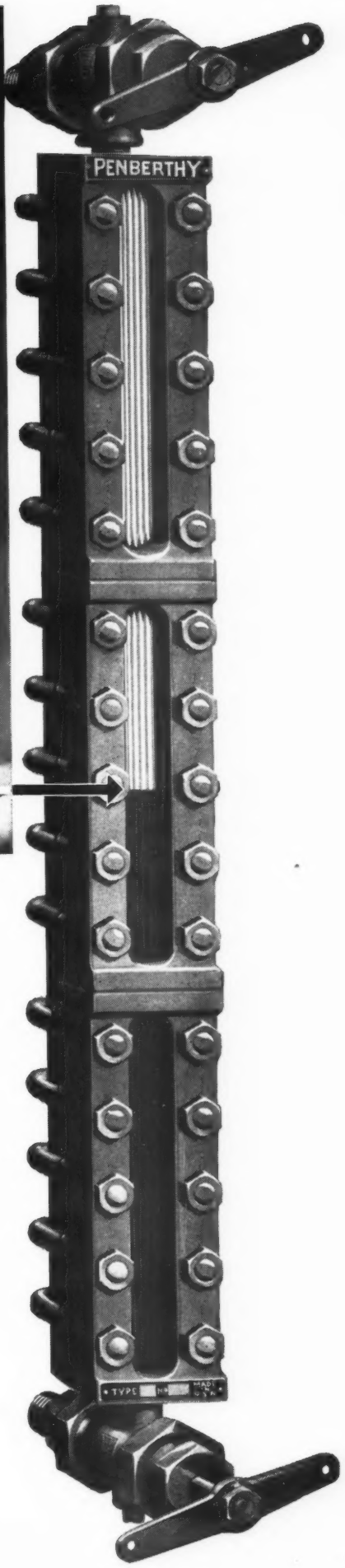
WHEN YOU MUST

BE SURE

OF THE

LIQUID LEVEL





Use

PENBERTHY "REFLEX" GAGES

DROP FORGED STEEL

There can be no error in reading the liquid level when you depend upon Penberthy "Reflex" Gages. The contrast between the black portion of the glass showing liquid and the white portion showing empty space is sharp and unmistakable.

Penberthy Drop Forged Steel Reflex Gages are available in whatever lengths required and for various liquids; they meet API—ASME requirements and are recommended for pressures up to 3000 psi at 100° F and 1000 psi at 1000° F.

PENBERTHY PRODUCTS

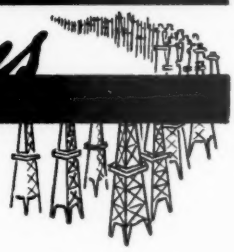
PENBERTHY INJECTOR COMPANY

Manufacturers of Quality Products Since 1886

DETROIT 2, MICH. • ***Canadian Plant—Windsor, Ont.***

2286

current oil field operations



Exploration wells that have found production.

● **ILLINOIS.** Gulf 5 Community Buehler SW NW 1-1n-1w Clinton. Pumped 183 BOPD Trenton 3940-46 ft. New sand.

NAPC 1 McElready SW SW SE 17-1s-4e Jefferson. Oil from Aux Vases 2627-647 ft.

● **WYOMING.** Rocky Mt. Gas 1 Government NE SE NW 2-19n-88w Carbon, 300 BOPD 43.2° Tensleep 6072 ft.

Seaboard & Resolute 53-33 NPRR NW SW NE 33-58n-100w. DST 150 B oil & 1 MMCF gas Phosphoria 8495-525 ft.

Stanolind 1 Unit SW SE NE 24-51n-93w, Torchlight field, Big Horn. 1632 BOPD 35.2° Tensleep 3140 ft.

● **OKLAHOMA.** Magnolia 1 Central Commercial CNE SW 25-5-4 McClain. 12-hr test 576 B 43° oil Bois d'Arc 9745-90 ft.

Shell 1 Walters C NE SW 14-10n-21w Beckham. 469 B 60° cond & 5736 MCF gas daily 9260-360 ft.

Western & Gulf 1 Hamilton NW SE SW 11-3n-2w Garvin. 288 B 41° oil in 19-hr Simpson 5764-73 & 5776-88 ft.

Texas 1 Lindsay SE SE SW 6-4-3w Garvin. 142 B high gravity oil in 6-hr Bromide 10,016-26 ft.

Deardorf 1 Heinzig NE NE SW 5-11n-6e Pottawatomie. Swb 85 BOPD Skinner 3261 ft.

O. E. Dempsey 1 Tract-18 SE SE NE 15-20n-10e Osage. 54 B oil in 8-hr & 7 MMCF gas daily Tucker 2173-86 ft.

Carter 1 Walter Buckholts NW NE NW 23-2-2w Garvin. Swb 137 B oil in 10 hr from 6600 ft.

Carter 1 Emberlin CSE SW 31-2-1w Garvin. 302 BOPD 41.8° third Deese 6236-74 ft.

Skelly 1 Adam CSW NW 29-13-2w Oklahoma. DST 5 MMCF gas daily Pennsylvanian 6162-235 ft.

Keener 3-A Jackson SE NE NE 29-7n-7e W. Transco field, Seminole. 200 B oil & 3 MMCF gas daily Senora 1770-85 ft.

Gas & Oil Industries of Okla. City 1 Thompson CNW NW 3-9n-9e Papoose field, Hughes. Swb 50-60 BOPD Booch 2719 ft. New sand.

Mid-Continent 1 Berry estate NW SW NW 32-9n-3w McClain. 70-min DST 500 MCF gas & 4500 ft 40° oil Bois d'Arc 8801-46 ft.

Sinclair Prairie 1 Tulsa University NW NE SW 33-2-2w Garvin. 574 BOPD Gibson 6418-36 ft.

L. A. & C. L. Culbertson & A. Brown 5-A Sarah Fields NE NE NE 17-16n-15e Wagoner. Est. 100 BOPD 39° second Wilcox 1850-55 ft.

British-American and Harper & Turner 1 Kramer CSW NW 13-12n12w Oklahoma. 2740 MCF gas daily Hunton 6265-71 ft.

Hughes & Sistrunk 1 GM&O, C SW SW 24-9n-8w Wayne. 30-min DST 220 ft oil from 5127-150 ft.

● **LOUISIANA.** Ken Meredith 1 South Coast Corp., Raceland field, Lafourche. 200 BOPD 38.6° from 10,010-25 ft. New sand.

Pan American 1 Elva Rugg CNE SE 31-20n-1w, D'Arbonne field, Union. 88 B 59° cond PD Bodcaw 8386-402 ft. New sand.

Vincent & Welch 1 Fee 14-6s-13w Beauregard. 58 B 59.7° cond daily from 7899-904 ft. New sand.

Shell 40-A Wilbert 8-11s-12e Iberville. 130 BOPD 23.8° from 3740-50 ft.

Atlantic 2 Haas Investment 9-2s-2e David Haas field, Avoyelles. 145 BOPD 8470-90 ft. New sand.

● **NEW MEXICO.** Amerada 5 Phillips CNE NE 1-20s-36e, Monument field, Lea. 30 MMCF gas & 25 B cond PH 9953 ft.

Cole-Darden 1 Phillips-State SE SE 30-17s-34e Lea. 305 B oil in 20 hr lime 4760 ft.

H. Yates 3-B Ballard SW SW 8-18s-29e Eddy. 75 BOPD 2620-60 ft. New sand.

● **UTAH.** Taylor Bros. 1 State CNW 33-21s-23e, Grand. 30 B 34° oil in 8-hr Ferron 1700 ft.

● **KANSAS.** Drillers Gas 1 Rombach NW NE 11-27s-1w Sedgwick. 100-150 BOPD 2715-20 ft.

Hendron Drlg 1-A McCauley SW SW SW 6-18-13w Eveleigh field, Barton. 391 BOPD Lansing-Kansas City lime 3177-81 & 3188-92 ft. New sand.

Gulf 1 Larimer C SE SW 36-31-20w Comanche. 26 BOPD Mississippi 5191-94 ft.

Continental 1 Finnely SE SE NE 14-10-18w Rooks. 25 BOPD Kansas City lime.

M. B. Armer et al 1 Catudal NE NE NE 23-10-19w Rooks. 25 BOPD Kansas City lime.

A. Goering et al 1 David H. Wenger NW SW 11-21-3e Marion. 35-40 BOPD Misener sand 2775 ft.

J. F. Leiker et al 1 Skelnar NW NE NW 33-18-4e, Marion. 20 BOPD Kansas City lime. 1837-70 ft.

Ohio I Livingston C SE SE Kingman. DST 500 MCF gas 3012-30 ft.

J. Lindas 1 Hutchinson SE SE NW 17-23-17w Pawnee. 5 BOPH Kinderhook 4301 ft.

● **MONTANA.** A. B. Cobb 1 Miller NW NE NW 15-37n-5e Liberty. 10 MMCF gas Colorado Shale 1780 ft.

● **GULF OF MEXICO.** Kerr-McGee 1 10-mi off Point au Fer, Terrebonne, Louisiana. 600 BOPD 25° 1734-50 ft.

● **TEXAS.** L. H. Smith 1 List, blk 2330, TE&L sur, N. Texas field, Throckmorton. DST 200 ft oil Caddo lime 4067-77 ft.

J. H. Snowden et al & L. H. Freedman 1 Marrs, blk 289, BBB&C sur, Throckmorton. 1-hr DST 140 ft 38.9° oil from 4729-43 ft. Oil from 4755 ft.

Byrd Frost 1 Mayberry, sec 39, blk 31, H&TC sur, Crockett. Oil from Wolf Camp lime.

Texas Pacific Coal & Oil 17-E Jackson sec 17, blk A-32, Fullerton pool, Andrews. Oil from Wolf Camp lime. New sand.

F. M. Manning 1 unit K, R. A. Brown, blk 261, BBB&C sur. Throckmorton. Oil from Caddo 4456-61 ft.

Lone Star Prod. 2 Clarence Rea, H. Greer sur No 62, Hamilton. 12 B oil in 2-hr from Marble Falls 2795-811 ft. First oiler in gas field.

S. D. Johnson & Acme Die & Machine 1 Mobley, Morehead sur, Clay. 192.78 BOPD 43° Strawn sand.

Warren 1 Ida E. Brooks, Russell sur, Young. 1-hr DST 20 ft oil 3654-62 ft.

Coats & Foster 1 Scott Ranch, W. McClellan sur, Comanche. Swb 50 BOPH Ellenburger 3526-28 ft.

Luling 26-B W. W. Boyce, 1-mi. from Burnell-Wilcox field, Karnes. DST 480 ft oil from 6847-50 ft.

Cox & Hamon 15 Neu, BBB&C sur, Walnut Bend field, Cooke. 229 BOPD Ellenburger 5240-390 ft. New sand.

Skelly 1 L. E. Adrian, sec 53, blk 20, T&P sur, Nolan. 68 B oil in 34 hr from 6340-64 ft & 6368-88 ft.

Cox & Hamon 15 NE, BBB&C sur, Cooke. 229 BOPD Ellenburger 5240 ft.

Fullerton & Ryan 1 Roemer, Calhoun. 20-min DST 2400 ft 44° oil from 7680 ft.

Gulf 20-B-E Connell, sec 26, blk B-16 PSL sur, Jordan pool, Ector. 1 hr DST 110 B 42.6° oil Silurian 7530-80 ft. New sand.

Continental 1 L. M. Bentsen, Sr., Los Guages grant, Hidalgo. 1-hr DST 10.5 B oil 5266 ft.

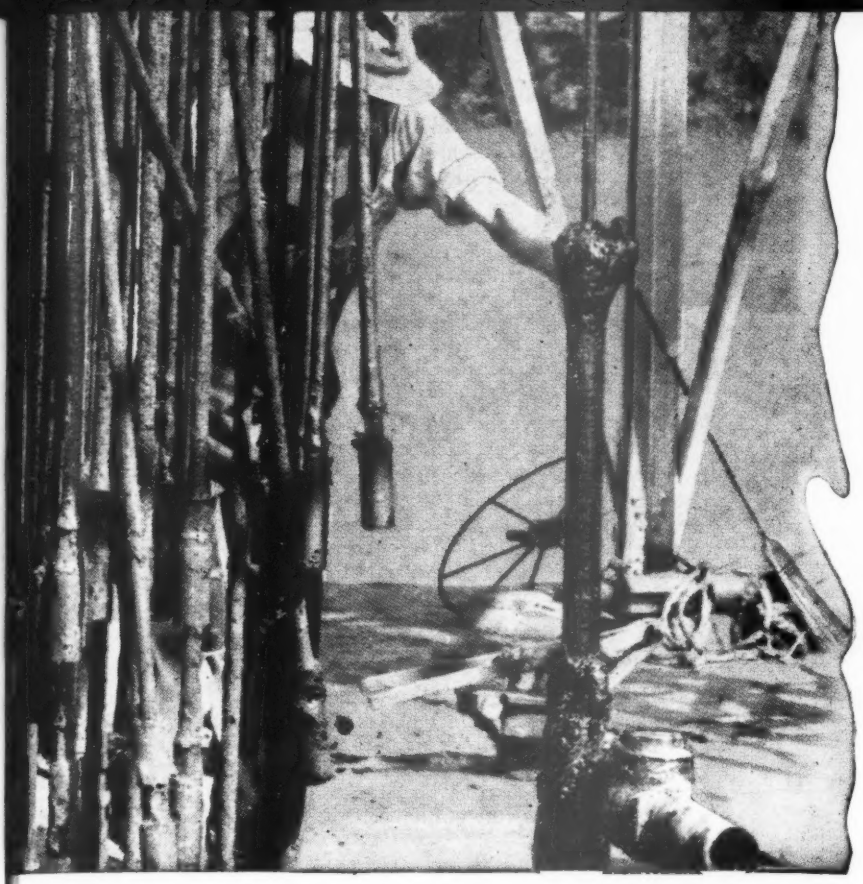
● **CANADA.** Calif. Standard & Imperial 1 Bantry 150-mi SE of Calgary, Alberta. 24° oil from 3259 ft.

● **KENTUCKY.** O. O. Borden 2 O. C. Whitfield 1-K-25 Hopkins. 100 BOPD Tar Springs.

● **INDIANA.** W. A. Schuller & W. H. Ramsey 1 Frank Steiner SE NW NW 24-2s-10w Gibson. Pumped 168 B oil in 20-hr McClosky 1956-1960 ft. New sand.

Joe Reznik 1 Weber NE SE SE 30-2s-9w Gibson. Swb 22 B oil in 8 hr. Renault 1819-23 ft & McClosky 1849-53 ft.

Joe Reznik 1 W. F. Fell SW SW SW 28-4s-10w Vanderburgh. 1 hr DST gas, 1820 ft oil McClosky 2210-14 ft.



Not a pretty picture—

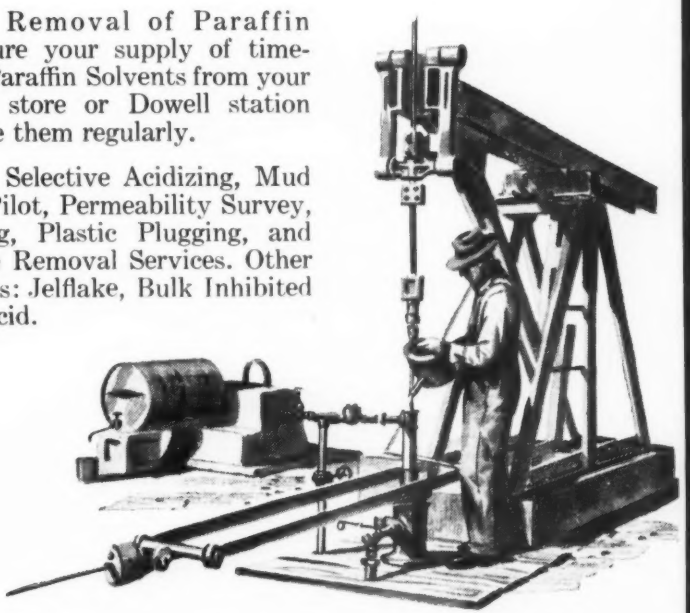
Paraffin deposits can result in bent or broken polish rods, excessive pump wear, parted sucker rods, failure of working barrels, burst tubing, expensive overloading of pumping equipment, and gradual decrease of production.

DOWELL PARAFFIN SOLVENT dissolves paraffin in all kinds of weather!

Dowell Paraffin Solvents are designed to *increase production* in pumping or flowing wells by dissolving the toughest paraffin—even when complicated by impurities such as salt or sand. The correct Dowell solvents are also effective in cleaning lead lines, tank bottoms, screens, liners, perforations, and in re-running rods.

Ask for your free copy of the interesting illustrated handbook—"Time Proven Methods for Removal of Paraffin Deposits." Secure your supply of time-tested Dowell Paraffin Solvents from your nearest supply store or Dowell station right away—use them regularly.

Ask also about Selective Acidizing, Mud Acid, Electric Pilot, Permeability Survey, Water Locating, Plastic Plugging, and Industrial Scale Removal Services. Other Dowell Products: Jelflake, Bulk Inhibited Hydrochloric Acid.



DOWELL

WEST TEXAS EXAMPLE:
Operator applies Dowell Paraffin Solvent regularly every week. Average cost $10 per well per month. Stuffing box is removed, 2 gallons Dowell Paraffin Solvent mixed with 4 gallons casing head gasoline is poured into well head. Well is shut in 24 hours, then put on production again. Running paraffin knife is eliminated, paraffin accumulation in flow lines avoided.

DOWELL INCORPORATED • TULSA 3, OKLAHOMA
Subsidiary of The Dow Chemical Company

Look to

FOR OIL INDUSTRY CHEMICAL SERVICE

pipeline developments

● **CITIES SERVICE EXPANDS SERVICE FACILITIES.** Cities Service Gas Company has been authorized to construct facilities to obtain additional gas supplies for the next two years.

Facilities will include construction of 10.5 miles of 16-in. line into Grady County, Oklahoma, to be used to reach further supplies of gas, particularly those to become available under the contract with Consolidated; 47 miles of 16 and 12-in. line to extend from near Guthrie on the company's main Wichita-Oklahoma City line on the west side of its system to its Drumright Compressor Station on the east side of the system; and about 15½ miles of 16-in. line to replace and shorten about 19 miles of its Tallant-Hogshooter 12-in. line. The total capital cost of these facilities has been estimated at $1,490,683, all of which the company proposes to finance out of cash on hand.

● **THREE EASTERN COMPANIES PLAN EXPANSION.** The Home Gas Company, The Manufacturers Light and Heat Company, and Cumberland and Allegheny Gas Company propose to construct and operate natural gas transmission facilities to enable them to provide more adequate service.

Total net cost of the facilities proposed has been estimated at $2,690,164.

Home Gas Company proposes installation of measuring and regulating stations in Deer Park Town, New York; construction of 52 miles of 10 and 12-in. lines; and the installation of an additional 1000 hp, a measuring station, and a dehydration plant at the Dundee Compressor Station. Cost of these facilities has been estimated at $1,850,155.

Facilities proposed by Manufacturers Light and Heat include an aggregate of about 7½ miles of 14-in. line; installation of a 1000 hp compressor station in Chester County, Pennsylvania; installation of an additional 375 hp unit at the Waynesburg compressor station, a measuring station and a regulator station in Chester County. Net construction cost of the facilities has been estimated at $709,740.

Cumberland and Allegheny Gas Company seeks to install 7 miles of 6-in. gas line at a cost of approximately $130,269.

● **PIPE LINES AND STORAGE SCHEDULED FOR DETROIT.** Michigan Consolidated Gas Company and Austin Field Pipe Line Company together plan to construct facilities to be used by Michigan Consolidated for transportation of gas received from Panhandle Eastern Pipe Line Company to the Austin Storage Field for subsequent withdrawal for service to the Detroit area.

Under an FPC order, Austin Field Pipe Line was authorized to construct a 26-in. or 24-in. pipe line about 140 miles long extending from Austin Storage Field to near Detroit, a metering station at the Detroit terminus of the line, and a gas compressor station of 3000 hp at the Austin Storage Field. Michigan Consolidated was authorized to lease and operate these facilities and to construct and operate a 26-in. or 24-in. line extending from the eastern terminus of the Austin-Detroit line to Melvindale, Michigan, and to install certain facilities in and operate its River Rouge Station at Melvindale to transport natural gas received from Panhandle Eastern to the Austin Storage Field and to construct and operate facilities in the Austin field for the storage and withdrawal of the gas.

Cost of the facilities authorized to be constructed by Austin Field Pipe Line has been estimated at $8,151,000 and those to be constructed by Michigan Consolidated at $1,174,000.

● **STAKE TRANS-ARABIAN LINE'S ROUTE.** American engineers, ranging in three groups over the rugged desert terrain of the Middle East, are rapidly completing preliminary field work along the 1040-mile route of the Trans-Arabian Pipe Line Company.

B. E. Hull, president of Trans-Arabian Pipe Line Company, reported that work of staking out the route from the Abqaiq oil field in Saudi Arabia to a Mediterranean terminus on the Lebanese coast near Sidon is progressing "according to plan."

The huge 30 and 31-in. pipe line, designed to bring Arabian oil to European markets, is expected to be ready for operation by 1950. It will be capable of carrying 300,000 bbl of oil daily for European use, thereby relieving the unprecedented demands on United States petroleum sources.

Working westward across the desert, where summer temperatures often reach 130 degrees, a survey party in Saudi Arabia has set location stakes for the line's first 100 miles, commencing at Abqaiq. A central survey party, working eastward from the "angle-point" in Iraq Petroleum Company's pipe line in Trans-Jordan, has completed final location as far as the Saudi Arabian border. In the rough, broken terrain at the western end of the line, a third party has completed reconnaissance work from the Mediterranean coast across Lebanon and beyond into Syria.

Unloading terminals for the thousands of tons of construction supplies and equipment, which must be brought in by ship during the next two years, are being established at Ras el Misha'ab, a sandy point on the upper reaches of the Persian Gulf, and at Beirut harbor, Lebanon. From Ras el Misha'ab, 150 miles northwest of the Abqaiq field, trucks will fan out across the desert to the southeast, west, and to the south, carrying these materials to the entire easterly portion of the project. A like operation will be carried on from Beirut.

Initial offloading operations began at Ras el Misha'ab in July of this year using facilities of an entirely makeshift character and housing consisting of a 50-man tent camp. Today the field base camp at this point includes a kitchen, mess hall, and 10 prefabricated American bunkhouses already occupied. These accommodations, however, are only 20 per cent of the camp facilities that will finally be constructed at this point.

● **PIPE LINES IN WORK.** Some of the pipe lines now under construction include:

Texas Pipe Line Company has begun building 253 miles of 22-in. crude oil line from Midland to Wichita Falls, Texas. The job is to be completed about May 1, 1948, depending on pipe deliveries. Contractor is Latex Construction Company.

Tennessee Gas Transmission Company has completed 73 miles of 20-in. natural gas feeder line from Carthage, Texas, to Natchitoches, Louisiana. Latex Construction Company laid the line.

● **NEW GAS LINES FOR SOUTHEAST PLANNED.** Southern Natural Gas Company and East Tennessee Natural Gas Company have made plans to construct and operate new natural gas facilities upon approval by FPC.

Southern Natural proposes construction of additional main line facilities to increase its system capacity to 384,500,000 cu ft of gas a day and the construction of lateral line extensions to serve new markets in Mississippi, Alabama, and Tennessee, including Chattanooga, Tennessee.

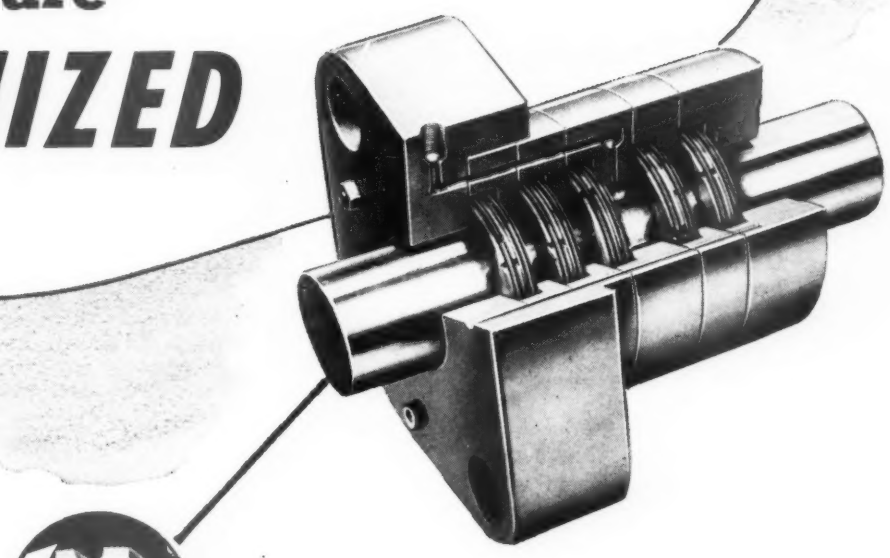
East Tennessee has requested authorization to construct a pipe line system from the main pipe line system of Tennessee Gas Transmission Company to serve a considerable portion of the Tennessee River Valley, including the cities of Knoxville, Chattanooga, and many other localities.

● **PLAN FACILITIES FOR BIG INCH GAS.** The East Ohio Gas Company has been authorized by FPC to construct and operate a 20-in., 84-mile pipe line to enable it to receive additional supplies of Big Inch gas. The overall cost of construction has been estimated at $3,200,900.

The company has taken preliminary steps and proposes to commence construction no later than February 1948 and to complete it within four months, the decision stated. East Ohio is presently purchasing Big Inch gas from Texas Eastern Transmission Corporation at a rate of 47,000,000 cu ft a day under an interim contract. Under a second contract, East Ohio is entitled during a term of 20 years to take additional quantities of gas as Texas Eastern enlarges its facilities.

BETTER PACKING FOR MORE EFFICIENT RESULTS—THROUGH METALLURGY

COOK PACKING RINGS are TINIZED



...to minimize friction and promote rapid seating

Designed so that an oil film is maintained between ring and rod, Cook Metallic Rod Packings function with minimum friction. But like a bearing that must be scraped to fit its shaft, a perfect mechanical fit between ring and rod must prevail. Otherwise, the oil film is impaired and excessive friction and wear may develop.

To eliminate this possibility during initial operation, Cook packing rings are Tinized—a process by which the bearing surfaces are coated with an anti-friction bearing metal that enables the ring to come to a rapid mating with the rod and reduces friction to the lowest possible point.

This Tinized surface treatment is another exclusive Cook feature—one of many that will pay big dividends if you specify Cook Packing when ordering new equipment. For existing machines, address us direct.

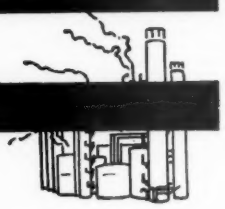
Sealing Pressures

Since 1888

C. LEE COOK MANUFACTURING CO.
INCORPORATED
LOUISVILLE KENTUCKY

BALTIMORE • BOSTON • CHICAGO • CLEVELAND • HOUSTON • LOS ANGELES • MOBILE • NEW ORLEANS • NEW YORK • SAN FRANCISCO • TULSA

refining and natural gasoline activities



● **GULF OIL PLANS BIG REFINERY EXPANSION.** Plans for improvements to the Ohio refinery facilities of Gulf Oil Corporation at Cincinnati and Toledo, to cost in excess of $20,000,000, were announced by Gulf officials.

The program, which calls for large new catalytic cracking units at both Cincinnati and Toledo, will equip both refineries to produce higher octane gasolines and other petroleum products of improved quality, the firm said. Production at the Toledo plant will be increased 25 per cent and a modern laboratory will be built there. All the mechanical shops at Toledo will be centralized under one roof.

Contracts have been let and preliminary work begun at both refineries. Major construction is scheduled to start in early Spring and to be completed in 1949.

The Cincinnati refinery serves southern Ohio, Kentucky, eastern Indiana, and a portion of West Virginia. Its machine shop and other mechanical shops will be modernized and combined in one building. Additions will be made to the Cincinnati refinery laboratory and office building.

● **STANDARD CALIFORNIA PLANS UNIT.** Standard Oil of California has announced plans for immediate construction in Salt Lake City area of refinery unit costing more than $5,000,000, first step of long range refinery program to serve the intermountain region.

The firm said 6 months ago it would lay a 10-in. 181 mile 25,000 bbl per day pipe line from Rangely, Colorado, field where it is the leading producer to Salt Lake City. The two projects are timed for initial operations together if possible.

The refinery installation, scheduled for completion in a year, will make a limited number of products including gasoline, heating oils, and fuel oils. The design capacity is 25,000 bbl daily.

● **BIG WEST TEXAS PLANT SCHEDULED.** Witco Hydrocarbon Corporation expects to place in operation a natural gasoline plant and a carbon black plant early next July in the Barnhart field in Reagan field, West Texas.

Contracts exceeding $3,500,000 have been awarded to Fish Engineering Corporation of Houston, which has ordered materials and expects to begin construction in January or February. Around 2000 bbl of natural gasoline, propane, and butane will be produced daily by the gasoline plant, and burning of the residue gas will yield approximately 750,000 lb of carbon black monthly. The Santa Fe railroad will lay tracks to each plant, to be situated on 80-acre sites about 2 miles apart.

Forty-eight wells in the Barnhart field produce more than 12,000,000 cu ft of gas with 5300 bbl of 44 gravity oil daily from the Ellenburger at 9000 to 9100 ft. The Witco Hydrocarbon Corporation is headed by Robert Wishnick of New York City. W. F. Donald of Houston, formerly of Oklahoma, is vice president and will be in charge of the plants in the Barnhart field.

● **BRAZIL PLANS NEW REFINERY.** A $2,0000,000 contract has been signed between Brazilian officials and a New York contracting firm to erect an oil refinery in Belem, with a daily capacity of more than 2500 bbl. The work, to be finished in 18 months, will be carried out by the Kellogg Pan American Corporation, a subsidiary of the M. W. Kellogg Company. The latter will supply all materials. The National Petroleum Council—an official organization—awarded the contract.

● **NATURAL GASOLINE PLANT FOR KANSAS.** Stanolind Oil and Gas Company has applied to Kansas Corporation Commission for a certificate for construction of a natural gasoline plant near Ulysses, Kansas, with capacity to utilize approximately 100,000,000 cu ft of Hugoton field gas per 24-hr day in the production of liquefied petroleum gases and natural gasoline.

Stanolind's application indicates a 24-hr productive capacity of 36,594 gal of liquefied petroleum gases and 26,663 gal of 12 to 26-lb Reid vapor pressure natural gasoline, by "absorption" process.

● **INCREASES FUEL OUTPUT.** A shift in refining operations to produce more fuel oil and less gasoline was reported November 25 by M. J. Rathbone, president of Standard of New Jersey, a refining and marketing subsidiary of the Standard companies.

The statement was made before a Senate committee investigating the fuel oil distribution situation in the face of what Chairman Wherry (R., Neb.) said looks like a "serious shortage that may mean many oil-burning homes may go cold this winter."

Rathbone's prepared statement said Standard Oil since early spring has been attempting to warn its retailers, distributors and the public of the prospective fuel oil shortage, caused by an unprecedented postwar demand for all types of petroleum products.

Rathbone said the greater emphasis now being put on production of fuel oil means less gasoline for motor vehicles but "my own opinion is that no customer of ours is going to be without heat this winter (or) kept from normal driving."

● **UNITS FOR RUSSIA HELD.** An estimated $7,000,000 worth of gasoline cracking plant equipment, originally intended for shipment to Russia, was turned over by the State Department to the War Assets Administration for disposal as surplus.

The equipment originally was scheduled for shipment to Russia to expand the capacity of plants sent the Soviet Union during the war under lend-lease, it was stated by George Truesdell of the Lend-Lease division. It was not shipped before the December 31, 1946, deadline for lend-lease consignments, however, and has remained in this country.

Truesdell said he understands that "no complete plant is involved; that is, one which would take crude oil and turn out gasoline." He said, however, that "whole units for adding to existing plants" are involved.

● **REFINERIES SOLD BY WAA.** Sale of a government-owned refinery near Catlettsburg, Kentucky, to its wartime operator, the Ashland Oil and Refining company of Ashland, Kentucky, for $2,150,000 was announced by the War Assets Administration.

The plant, a catalytic cracking and treating unit, was operated during the war for the production of 100-octane aviation gasoline. It will be used by the purchaser primarily for the production of motor fuels, attracting approximately 216 workers.

A Pasadena, Texas, 100-octane refinery, operated for the government during the war by the Crown Central Petroleum Corporation, has been sold to that corporation for $2,300,000 by War Assets Administration. Production facilities include a thermofor catalytic cracker of nominal 10,000-bbl-per-day capacity, a treater of nominal 5000-bbl-per-day capacity, an HF alkylation unit with a capacity of 3500 bbl per day, and a butane isomerization unit.

● **STANOLIND TO BUILD NG UNIT.** Stanolind Oil and Gas Company has announced its intention of building a natural gasoline plant in the Levelland Field, Hockley County, Texas.

This plant will conserve gas being produced from the Levelland Field. Other producers in the field will be given the opportunity to participate in the plant ownership. Pressure maintenance is being investigated, and if it should be found desirable the plant will be equipped with facilities for returning high pressure gas to the leases for reinjection.

● **NATURAL GASOLINE PLANT COMPLETED.** The Hiwan Oil and Gas Company's natural gasoline plant in the Atlanta field, 15 miles east of Magnolia, Arkansas, has been put into operation, it was announced last month.

The company, with principal offices in Houston and Denver, began construction of the plant eight months ago. The plant was designed to process 10,000,000 cu ft of gas daily for production of 35,000 gal of natural gasoline and liquefied petroleum gas.

Fifty-three wells in the Atlanta field have connections with the plant, which sells its gasoline to Lion Oil Company, and its liquefied gas to Paxton & Wright, both of El Dorado, Arkansas.

THE Petroleum Engineer
DECEMBER, 1947

Postwar progress in the Iranian oil fields*

THE maximum producing capacity of the Anglo-Iranian Oil Company in South Iran before the war was about 13,800,000 tons annually, and in 1940 with the development of the new field in Gach Saran, and the completion of the pipe lines to this area, this capacity was increased to 15,500,000 tons annually divided as follows:

EXCLUSIVE

Masjid-i-Sulaiman field, tons	3,800,000
Haft Kel field, tons	10,000,000
Gach Saran field, tons	1,700,000

(Editor's note: Production for Anglo-Iranian Oil Company in August, 1947, was 2,056,000 tons, or at the annual rate of 24,672,000 tons).

The production of the first two named fields, however, was near the limit of their maximum potential, whereas the crude produced from Gach Saran was of a heavier grade yielding a lower proportion of the more useful light products benzine and gas oil. Fields shut down at the beginning of the war were the following:

1. The Lali field where oil had been proved but no commercial production had been obtained.

2. The White Oil Springs field where commercial production had been proved, but reserves were small and well siting difficult.

3. The Agha Jari field where commercial production was available in a convenient geographical position for the rapid and economical laying of pipe lines.

Although the drilling problem in the Agha Jari field was a difficult one, it was decided to develop this field as rapidly as possible for the production of 6,000,000 tons annually to be obtained by 1945. This was to be carried out in two stages —a temporary unit for the production of 3,000,000 tons annually being the first stage, to be followed by a permanent unit of 6,000,000 tons capacity. In order to safeguard the position and relieve the strain on the Masjid-i-Sulaiman and Haft Kel fields it was also decided to recommence drilling and development in the Lali and White Oil Springs areas. (Fig. 1).

● **Development of the Agha Jari field.** Work was begun in the Agha Jari field in the autumn of 1943, five strings of tools being put into operation with four drilling crews. The problem of rapid development was a difficult one, for prior to the war this area had only been worked on a prospecting basis, and only temporary services had been installed. Water and power supplies, workshop and transport services, and accommodation, were all on this small scale.

The producing area lay in very broken terrain, varying from 500 to 1200 ft in elevation, making the construction of roads, pipe tracks, and the selection of rig sites matters of extreme difficulty. (Fig. 2).

The main supply center is some 100 miles away. Into this area it was necessary to ship material at the rate of 5000 tons a month, and staff members and laborers totaling some 5000 persons had to be fed and found accommodations. The work necessary to attain the production target of 6,000,000 tons annually included:

- Drilling 12 wells each 8000 ft in depth.
- Erection of temporary stabilization unit.
- Erection of permanent 6,000,000 tons annually stabilization unit.
- Increasing water supply to 2,000,000 gal per day with tankage and reticulation system over an area of some 50 sq mi.
- Installing 1000-kw power generating units and distribution system.
- Opening up some 75 sq mi of producing area.
- Laying 500 miles of pipe line varying in size between 12 in. for main oil delivery lines to 6 in. and 4 in. for local water supplies.
- Constructing over 100 miles of roads.
- Building temporary staff and labor quarters and camps.
- Extending workshops, garages, ice plants, and power plants.
- Installing stores depots for materials, provisions, clothing, etc.
- Organizing ration distributing centers, medical centers, and sanitation depots.
- Building offices, yards, dumps, etc.
- Installing recreational facilities.

● **Drilling.** The reservoir rock in the South Iranian oil fields is the Asmari limestone, which occurs in long regular folds running northwest and southeast and, in the producing areas, is found at depths varying from 1000 ft to 10,000 ft.

In the Agha Jari field wells are between 6000 ft and 8500 ft deep. (Fig. 4.)

The upper formations, sandstone, limestone, and shale present no special problem.

In the lower Fars, however, where gypsum and calcareous shales predominate many difficulties are encountered particularly on the southwest flank where confused formation conditions make correlation difficult. Formation pressures of the order of 1.1 psi per ft of depth prevail in the strata overlying the cap-rock and these are accompanied by high pressure water and gas shows in varying degree. Even if water is not present squeezing of the formation occurs on both flanks and maintenance of a heavy mud column or its equivalent is essential.

The difficulties are complicated by the chemical content of the water and be-

*Prepared especially for *The Petroleum Engineer* by Anglo-Iranian Oil Company, Ltd.

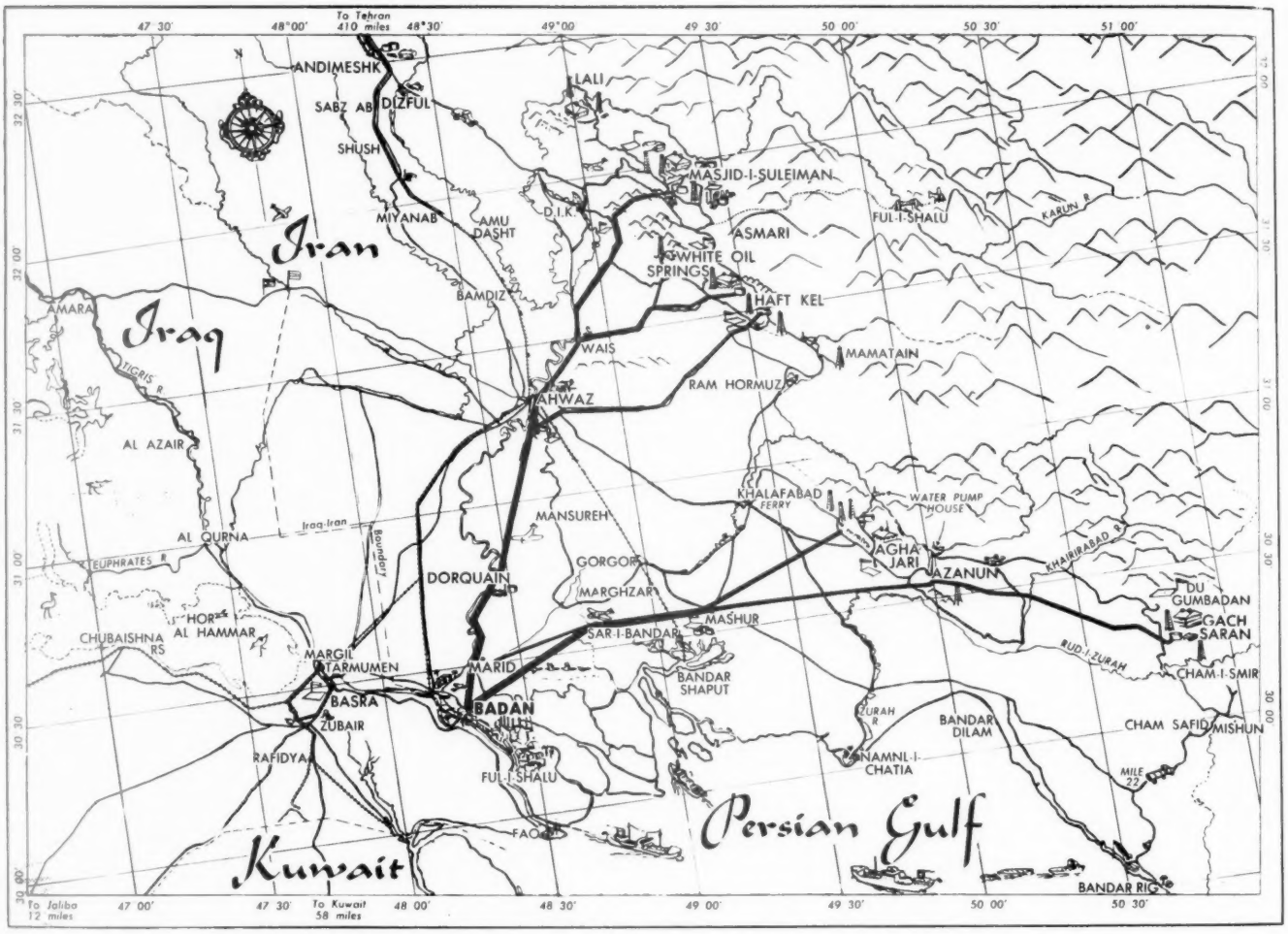
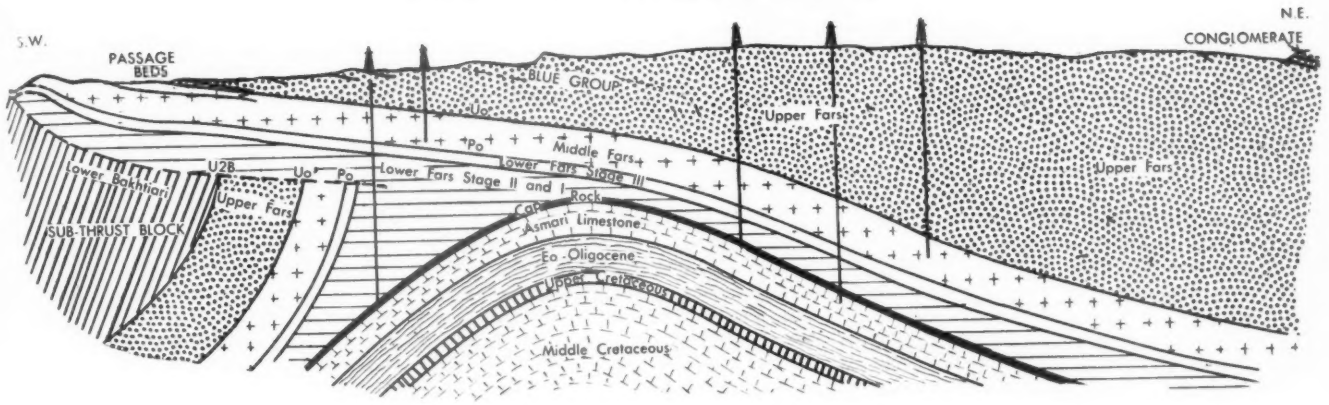


FIG. 1. Map showing the Anglo-Iranian Oil Company's fields and pipe lines in South Iran.

FIG. 2. Typical terrain in the Agha Jari field.

FIG. 3. Pipe line from the Agha Jari field.

FIG. 4. Section through the Agha Jari structure.



cause pressures are frequently not proportional to depth, in fact, the lower shows sometimes have a lower pressure than those above.

At first attempts were made to obtain control with weighted mud, making full use of developments in chemicals and proprietary products for control of viscosity, permeability, and pH value as they became known. However carefully the muds were prepared it was found difficult to keep them in condition and the loss of valuable weighting material and chemicals was high. In one well upwards of 70,000 cu ft of mud and sealing mixtures were used at one point without success. Gradually the general position of the shows was fixed and a semi-pressure drilling technique developed. Wells are drilled normally into the Middle Fars (5000 ft) and, before reaching the first expected trouble spot, pressure drilling equipment is installed.

Locations are selected to give a 10-ft cellar, which with a 6-ft subcellar and derrick mounted on 6-ft piers gives 22-ft working height. This allows the installation of a Cameron blowout preventer, Seamark blowout preventer and gland packer. Suitable connections on the wellhead permit open circulation, under pressure, through beans to separators, to storage, or across the wellhead. The discharge from the beans flow to a Link Belt screen to remove cuttings not dropped in the separators, which consist of 10-ft lengths of flanged casing set to slope and on which beans are mounted. All wellhead mud controls are brought through the derrick floor in full view of the driller. A 17½-in. hole is first drilled to 1000 ft and if any show appears 15¼-in. casing is run and cemented to surface from a point below it. Otherwise the casing is run only to 500 ft. The next string (11¾ in.) is frequently set to case off the first main water show—usually about 3500 ft varying with position on structure. If this show is not completely sealed before casing is run the normal cementation is followed by pumping cement to the annular space amounting to several times its calculated volume. After the cement has set a test pressure is applied to the annular space and further cement squeezed in if needed. This method has proved very successful and on one occasion casing was run and cemented against a flow of 12,000 gal per hr.

Pressure drilling gear is installed before entering the pressure zone and light mud is used with normal back pressure of the order of 800-1000 psi, although this varies with position on the structure and may be as high as 1600 psi. The pressure is adjusted to meet the changing conditions and a balance maintained in drilling through and beyond a bad spot. When making a round trip the bit is pulled to the casing shoe under pressure and the light mud then displaced by a column of sufficient weight to maintain the same pressure below. Back pressure is reduced as the change is effected and a straight forward pull out is then made. When running in the procedure is reversed—with the bit at the casing shoe the heavy mud is circulated to storage for re-use and back pressure gradually applied. By this means the use of snubbing equipment, with its attendant danger and delay, is avoided.

By adjustment of the pressure, squeezing is prevented and quite a delicate balance can be maintained. The bit is pulled to the shoe once per shift or oftener as required, to check the condition of the hole. A round kelly and Guiberson drive are usually fitted, and the gland packer can be arranged to rotate to reduce wear on packing to that of vertical movement only.

In general the method employed gives control impossible by other means, avoids heavy loss of weighting material, and, by adjusting weight of mud and pressure to the proper combination, a correct pressure differential between any two points in the hole can be maintained. For instance, with two shows in the hole separated only by a few hundred feet, a mud column of sufficient weight to control the upper show sustains a heavy loss to the lower show. With light mud and back pressure a much lower differential is obtainable.

● **The production system.** Production practice in the Iranian fields employs a completely enclosed producing system whereby crude flows from the well into the collecting line without the customary separator installed at the wellhead. After passing through a battery of heat exchangers it enters the stabilization unit, which in seven stages of separation reduces the pressure to the required point. Leaving the last stage vessel it is delivered direct to the boosting pump, which injects it into the main pipe line system. No tanks are included in the system and by this means it is possible to deliver crude of varying qualities to the refinery. If, for instance, pressure crude is required, the pressure of the last stage is increased to the required degree and the crude enters the suction of the pipe line pump at that pressure. As at no time does the pressure in the pipe line drop below this point, the gas remains in solution until it reaches the refinery. Here it is fed direct into the benches, which are adjusted to receive it and process it at this pressure and by this means the maxium conservation of C_4 is effected. A vacuum stage is also included in the stabilization unit so that, when export crude is being delivered, all gas can be stripped from the crude and so stabilizing it that no losses will be incurred in tankers or export storage.

The number of wells allocated to supply the production units in Agha Jari was estimated to be 12, and in order to obtain the maximum production from each well, so that if necessary a reduced number might be used, large size flow lines of 6-in. and 8-in. diam, were laid between the wells and the stabilization units. Wells in this area are capable of producing from 500,000 and 1,000,000 tons annually (10,000-20,000 bbl per day) flowing pressures being between 1200 and 1500 psi.

● **The stabilization units.** The multistage system of crude stabilization previously had been installed in the Haft Kel and Gach Saran fields, and very satisfactory results had been obtained. The pilot plant erected in Haft Kel as far back as 1930 employed horizontal separators and on the record of this unit, the use of this type has been standardized throughout the Iranian oil fields.

The Gach Saran installation completed in 1940 embodied several new features. Here the unit was designed to handle 6,000,000 tons annually of crude through six horizontal separators 6 ft in diam and 100 ft long. An unusual feature of this installation is the system of automatic control that enables the production operator, sitting in his office remote both from wells and plant, to vary the

production of the field by the simple operation of turning a small handwheel set in a control board. The operation of this wheel, relayed to a flow controller set in the main pipe line, reduces the flow of crude passing along the line to the required rate. As only gravity flow or multistage centrifugal pumps are used on main oil lines, this restriction in flow backs up the level of the crude in the last stage separator at the stabilization unit where a level controller operates by pneumatic relay a flow controller on the inlet. This cycle is repeated from separator to separator as flow is restricted and levels rise, until the entire battery settles down to the new rate of throughput. The restricted flow is similarly communicated to intermediate stage separators set halfway between the wells and the unit and, in their turn, to the wellhead separator. Raising the level in this vessel operates a level controller and a pneumatic relay closes the flow controller on the well itself, thus completing the cycle. This train of operations carried out over a system of some 3½ miles from pipe line controller to the well and including eight different stages takes 20 min to complete.

The problem in Agha Jari presented one new feature: The temperature of the crude. In this new field the producing zone lies at depths down to 7500 ft below sea level and the temperature of the crude at the wellhead is about 140 F. In order to retain the light fractions in the crude so far as possible it was necessary to include in the Agha Jari stabilization units a battery of heat exchangers whereby the incoming crude is cooled by the outgoing crude, which has been cooled by the expansion of the gas.

At this time almost no material could be obtained from Britain on short notice; consignments of standard line pipe could indeed be obtained, but the specially designed vessels and equipment required for the stabilization unit could not be delivered in under two years. As production was required at the earliest possible moment, it was decided to design a temporary stabilization unit improvised from material existing in the country. This work of improvisation imposed a severe strain on the fields' workshops, each of which contributed a quota of fabricated parts, pressure vessels, instruments, pumps, etc. Every inch of pipe line that could be spared from other areas was pulled up and shipped to Agha Jari, and even pipe lines in less important services were requisitioned for this high priority project.

For power units two ancient steam sets long pensioned off were used and scrap heaps in all areas were sorted over for anything that might prove useful in the building of the Agha Jari temporary stabilization unit.

Heat exchangers were produced from oil-well casing inside which were welded nests of 2-in. high pressure tubing.

Site work was extremely difficult, for in this broken terrain a level site for such a layout was impossible to find; thousands of tons of hard rock and shale had to be levelled off on a hilltop. Installation was begun in the spring of 1944, and by the end of the year the job was completed and the new crude flowed down the pipe lines.

The permanent unit that followed for the higher throughput was supplied complete from the United States and United Kingdom. Brief details of the specification are:

Throughput, 6,000,000 tons annually (since raised to 8,000,000).
Gravity of crude, 36° API at 60 F.
Gas-oil ratio, 150 : 1.
Temperature, 140 F.
Well flowing pressure 1500/1600 psi.
Stages of stabilization:

First stage separation	1150 psi
Second stage separation	560 psi
Third stage separation	180 psi
Fourth stage separation	62.5 psi
Fifth stage separation	29.5 psi
Sixth stage separation	14 psi
Seventh stage separation	Atmospheric pressure

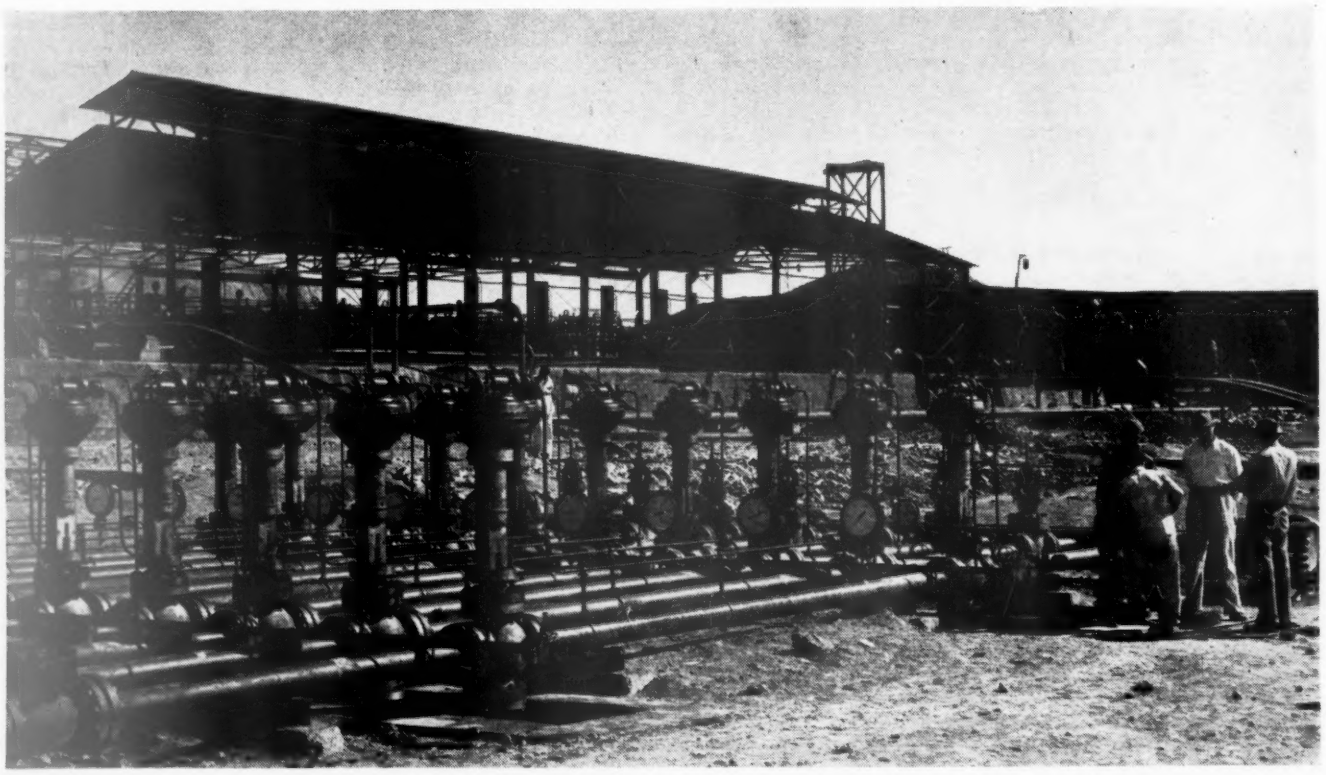
To this unit a vacuum stage working at an approximate pressure of 8 psia is being added. Automatic control is employed throughout the entire production system. (Fig. 5).

The high pressure separators used on this unit followed a new type of design known as the "multi-layer" pressure vessel developed by the A. O. Smith Corporation. This type of construction requires less steel than the solid wall vessel. A thin inner shell welded longitudinally is wrapped with several layers of relatively thin plate, each layer being welded before applying the next. This wrapping process exercises a compressive stress in the inner shell that, when the vessel is in operation, results in efficient stress distribution.

After fabrication the vessel is subjected to a pressure considerably in excess of the pressure specified for testing when installed. The layers are thereby consolidated. These separators are built in four sections each 25 ft long with conical gas and oil outlet sections. The diameter is 54 in. and the working and test pressures are respectively 1500 and 2250 psi. (Fig. 6).

A description of the heat exchange equipment may also be of interest. This installation consists of sixty 36-in. units and eight 18-in. units. The 36-in. units

Fig. 5. Automatic flow controllers on incoming manifold at Agha Jari stabilization unit.



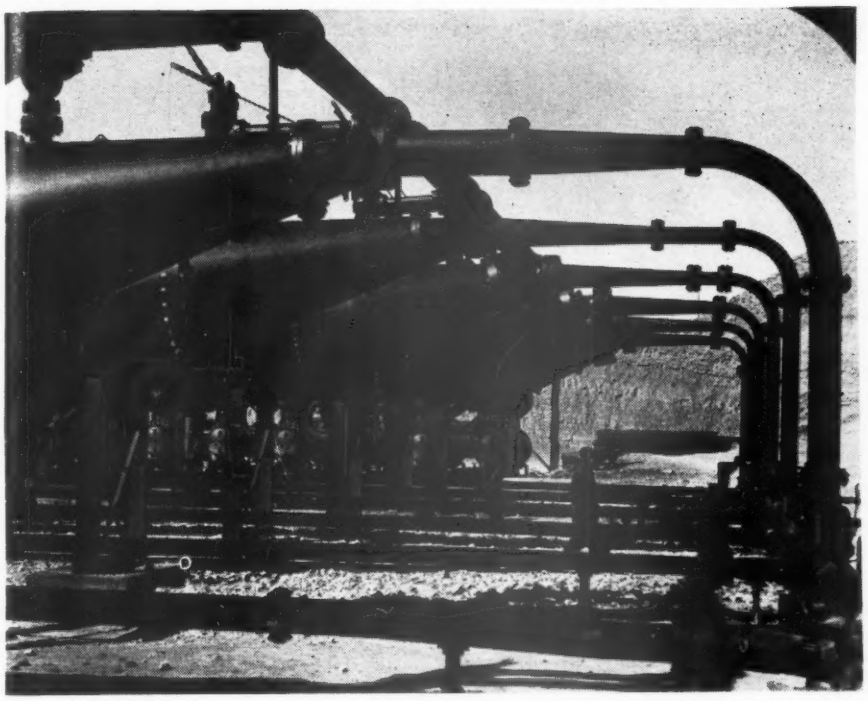


FIG. 6. View of outlet end of separators at stabilization unit.

operated as three in parallel and twenty in series cool a hot gas-oil mixture in the tubes at 1500 psi and 140 F by cold stabilized oil in the shell at 250 psi and 60 F, the expected final temperatures of the hot oil and stabilized oil being respectively 78 F and 135 F. The total surface area is 78,120 sq ft. The vessels were constructed to the API-ASME code, the shell being 9/16-in. thick and 36 in. inside diameter of welded rolled steel plate. Each unit contains 560 1-in. seamless steel tubes 16 ft in length. (Fig 7).

In the 18-in. units the cooling medium is gas flowing in the shell at 1500 psi at the rate of 1540 lb per min. This enters at 49 F and cools a gas-oil mixture flowing in the tubes at the same pressure and flow rate. The gas-oil mixture is cooled from 140 F to approximately 83 F. The total surface area of the eight 18-in. exchangers is 3840 sq ft.

The test pressures for the 18-in. exchangers are 2250 psi on both shell and tube sides and for the 36-in. exchangers 2250 psi on the tube side and 375 psi on the shell side.

The 1¼-in. thick shells of the 18-in. exchangers were manufactured in forged steel thus avoiding welding and the subsequent necessity for radiographic examination.

● **Pipe-line system.** Before the war the only two fields in South Iran delivering crude to Abadan were Masjid-i-Sulaiman and Haft Kel. The main oil pipeline system connecting these fields to the refinery at Abadan was made up of 850 miles of pipe line, a fourth of which was 10 in., the remainder being 12-in. diam. Since 1943 the length of oil pipe line has been almost doubled. (Fig. 9.)

All pipe lines laid before 1932 had screwed joints but after that date the AIOC standardized on 12-in. welded pipe 0.375 in. thick for heavy sections and 0.330 in. thick for normal pipe. Pipe-line practice in the AIOC oil fields follows somewhat different lines from that adopted in other parts of the world in that all lines are laid on the surface, the reasons for this being that the soil in most of the desert area is highly corrosive and it was found from actual experience that maintenance of pipe lines laid on the surface was more easily carried out. Repairs and painting were greatly facilitated and inspection was simplified. (Fig. 3.)

To allow for expansion and contraction during the extremes of temperature (varying as much as 100 F over 24 hr and 120 F between maximum and minimum for the year) the pipe is staggered and laid on bearers, which permit free movement. The degree of stagger is 12 ft in every 200 running feet of pipe. This makes an angle of 3° 29″ angularity from the true alignment, and the additional length added to the line is 10.6 ft per mile. (Fig. 8.)

The temperature of the oil in the lines varies between 280 F in winter and 140 F in summer, and the extremes of temperature prevailing over the 24 hr affect the delivery of oil in the line in a manner that presents an interesting problem to the pipe-line engineer.

The pipe lines in South Iran are all multiple systems so arranged that crude of differing qualities or topping plant products can be delivered from any field through isolated lines and in the event of surplus products accumulating in the refinery such products can be pumped back to the Masjid-i-Sulaiman field and to the reservoir. During the war this flexibility was of the greatest possible use enabling the correct range of products to be produced and exported, no less than 75,000 bbl of oil being recycled in 1943.

With the exception of Masjid-i-Sulaiman field, production units in the remaining fields are all sited at an elevation that enables them to deliver oil by gravity to the refinery if necessary, the flowing pressures of the wells being high enough to deliver crude to the production units.

The Gach Saran pipe line commissioned in 1940 is an outstanding example. Its length was 165 miles and the hydraulic gradient of the line necessitated a section of heavy pipe being inserted at a low point where the line leaves

FIG. 7. Battery of high pressure heat exchangers—stabilization unit.

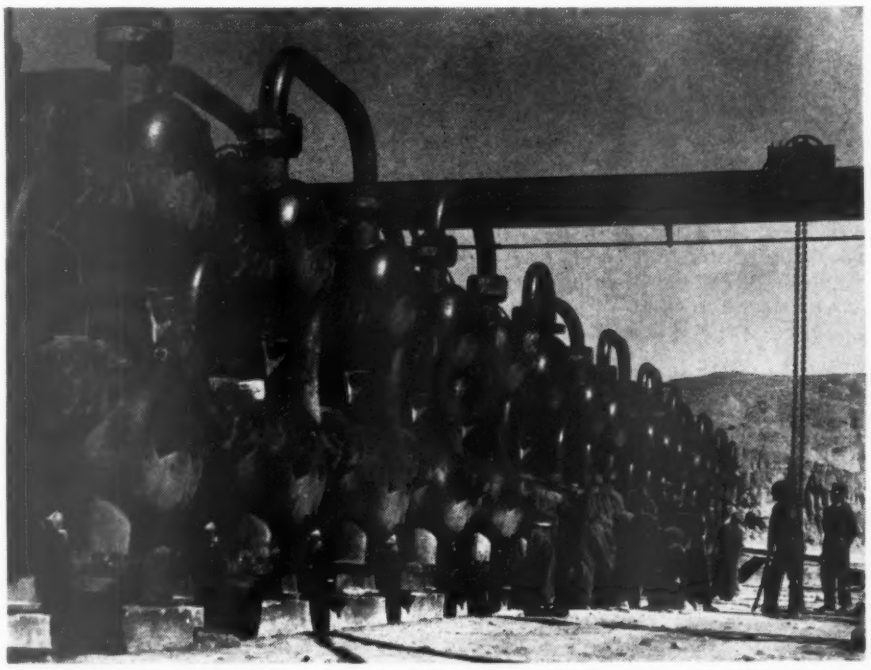


FIG. 8. The Agha Jari pipe lines in course of construction.

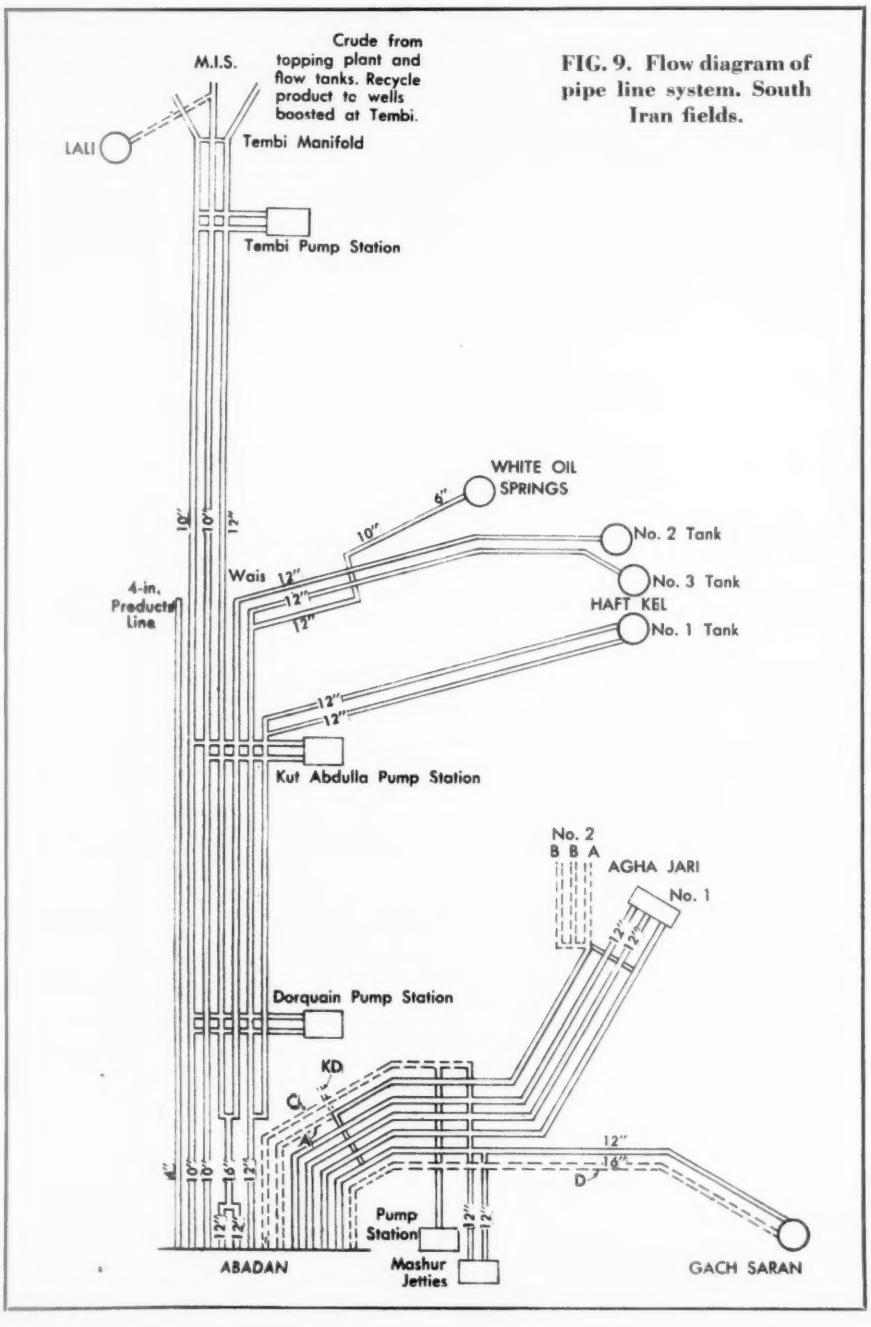


FIG. 9. Flow diagram of pipe line system. South Iran fields.

the foothills and crosses the low lying desert. The elevation of the Gach Saran Production Unit being 3000 ft above sea level, a delivery of 1,500,000 tons annually into Abadan can be maintained by gravity flow alone. The line was so designed, however, that its capacity can be raised to 2,500,000 tons annually by the installation of booster pumps at the field and at a point 100 miles down the line.

In order to make the fullest use of the pipe in the Agha Jari field, booster pumps are installed at the production unit. The standard unit adopted is capable of delivering 2,000,000 tons annually at a pressure of 800 psi and multiples of this size are employed. These sets consist of multistage centrifugal pumps, direct driven by impulse type turbines. The gas from the high pressure stages of the stabilization unit is used expansively in these turbines in place of steam, thus utilizing the power capacity of the high pressure gas available in the field.

The Agha Jari pipe-line system was begun in 1944. The first stage in the project included the laying of three 12-in. lines from the field to Abadan, a distance of 100 miles, and one 12-in. link to Mashur. Following the usual practice of the AIOC, these lines were welded and laid on the surface at the rate of 1 mile per day during favorable weather. Since the beginning of this project about 350 miles have been added to the AIOC pipeline system in the same area, the crude deliveries from the Agha Jari field having now reached 7,500,000 tons annually with further increases projected in the immediate future. But the day of the small size pipe-line system is over. Advances in manufacturing technique have now made larger sizes readily available and 16-in, 20-in. and 22-in. lines are on the program for future additions and although flexibility is, to some extent, sacrificed by this increase in size, the economy effected in steel consumption is considerable, for compared with 12-in. line the throughput per ton of steel is increased by 30 per cent when using 16-in. line, and is nearly doubled when using 22-in. line. ★★★

Making a tack weld. This photograph was taken near Bryan, Texas, where line runs through a wooded section.

Self-propelled motorized equipment features construction of products line

By FRANK H. LOVE, *Managing Editor*

EXCLUSIVE

With the first half of the products line being constructed from a point near Beaumont, Texas, to the Dallas-Fort Worth area completed and the second half well underway, it is expected that movement of the several grades of motor fuels scheduled for transportation through the system will begin before the first of the year. The section from Beaumont to Hearne is 12 in., and from Hearne to Dallas-Fort Worth area is 10 in. The line is being constructed by Magnolia Pipe Line Company and The Texas Pipe Line Company and each company will operate its section of the line. Magnolia, which laid the section from Hebert station near Beaumont to Hearne, Texas, already has completed its line. The Texas Pipe Line Company, delayed by inability to obtain delivery on line pipe, began its construction work about the time Magnolia was finishing up.

Although about 60 miles of the right-of-way was through rice fields in the Gulf Coast area, which presented problems and required engineering ingenuity, for the most part construction was more or less routine pipe line procedure. A feature of the work, however, was the use of self-propelled motorized equipment designed by O. R. Smith, head of the contracting firm, Smith Contracting Corporation. This equipment included the "dope" pots, air compressors, welding equipment, and water pumps, and its use is estimated to have hastened construction to the extent that the job was completed ahead of schedule.

Except for the dope pots, the self-propelled units consisted of conventional equipment mounted on a specially designed undercarriage. In the case of the welding machines, these were of standard manufacture, mounted on the undercarriage in a manner that power from the 300-amp welding machine engine also provided power to propel the entire unit. The undercarriage, in this instance, had four-wheel drive and hydraulic brakes.

The air compressor units used to test the line, and the pumping units used to dewater the ditch through the rice growing sections, likewise were mounted on four-wheel drive undercarriages, propelling the units in the same manner as the welding units.

The dope kettles used on the job, in addition to being self-propelled, also were of special design. The standard unit was a 22-bbl kettle mounted on a 4½-ton chassis with six-wheel drive. Conventionally they have two burners

The picture above shows clearly one of the self-propelled welding machines. Mounted on a special undercarriage, the entire unit is propelled by power from the 300-amp welding machine engine. Below the line pipe is being coated and wrapped.

Here the bulldozer has no trouble backfilling, but through some areas where rice crops had not been harvested it was necessary to backfill temporarily and await drier terrain to do the job permanently.

mounted permanently, with provision made for a third burner when desired. The agitator is driven by a power take-off from the motor chassis unit. The standard unit was used along the right-of-way by the two spreads. A 40-bbl unit also was employed for use as a coating transport unit to refill the smaller kettles. These were mounted on a 12-ton chassis with 12-wheel drive. The 40-bbl kettle was divided into two compartments of 20-bbl each, coating being withdrawn from one compartment at a time.

Additionally, a combination welding machine and dope kettle mounted on a single undercarriage was used for such utility work as making tie-ins at railroad, highway, and river crossings and coating the joints afterward. The dope kettle in this case held 6 bbl and the welding machine was 300 amp. This equipment was mounted on a 1½-ton chassis with 4-wheel drive, the entire unit being transported from the power end of the 300-amp welding unit.

Operating under its own power this equipment could traverse any type of terrain, requiring no equipment for towing. On this job it accelerated the work considerably, as has been pointed out. In addition the designer and contractor asserts that a saving in repair cost was effected due to the use of fewer items of equipment.

● **Construction difficulties.** The principal difficulties encountered in laying the line were presented by the rice fields

Handling the sections of pipe with a tractor and sideboom, the tack welds were made, followed later by the finishing welds.

Motorized "dope" kettle typical of those used on the construction job.

Special self-propelled air compressors of this type were used to test line.

along the Gulf Coast, as mentioned, and the crossing of several rivers.

Through the rice fields the pipe line ditch was dug with a backhoe, the line pipe welded up in sections and floated in, after which backfilling was with draglines. Initially, the backfilling was done roughly as the rice crops had not been harvested. After the crops have been harvested and the fields become dry a permanent job of backfilling can be done. The rice fields were encountered immediately out of the Hebert station and continued for a distance of 60 miles, although not uninterruptedly.

The river crossings were of the Trinity and San Jacinto. In both instances the water span was about 350 ft. The pipe actually under water, as well as that in the approaches, was cased in 16-in. casing. For the San Jacinto River crossing 775 ft was cased, whereas 500 ft was cased in the Trinity River crossing. In addition, the Trinity River bottom, south of Liberty, Texas, was particularly boggy at the time of construction and some 2000 ft of pipe had to be welded up and pushed into place because of inability of the heavy equipment to lay the pipe in the customary manner.

After making up the section required for the river crossing, the pipe was inserted into the casing, both ends sealed and the annulus filled with a corrosion inhibiting compound before the whole was pushed and pulled by tractors into a trench previously dug by draglines.

All railroad and highway crossings also were cased and such places were tested for leaks and faulty welds by the application of 100 psi air pressure. Sections of the line also were cleaned internally as the work progressed by propelling a "pig" through them by means of air pressure varying from 40 to 75 psi. The sections thus cleaned averaged 10 miles, although under certain circumstances these sections were sometimes as long as 15 or 16 miles.

Digging the trench into which the pipe will be lowered after it has been welded, coated, wrapped, and tested.

● **Pumping station.** Only one pumping station will be required on the Magnolia section of the system—at Hebert, as mentioned. This station is now nearing completion and two units consisting of 6-in. 4-stage centrifugal pumps driven by 400-hp 3600-rpm open motors are being installed. Initially, but one pumping unit will be used; as capacity is increased, however, the two units will operate in series. At such time another unit will be added as a standby.

The station building is divided between the pump and motor rooms with a firewall and the motor room is pressurized. The pump room is de-pressurized by means of an exhaust fan.

At this station there are seven floating roof type all-welded tanks, six of 80,000 bbl capacity and one of 55,000 bbl capacity. Each tank has individual lines from the incoming manifold to the tanks and all lines are aboveground.

Terminals will be provided at Houston, Hearne, Waco, Dallas, and Fort Worth. ★★★

Subzero weather in March, 1947, does not stop the flying gravity-meter survey party's operations. The ski-mounted Cessna 140 provides transportation for the instrument and crew of two between stations on the almost endless snow-covered wastes of NPR-4.

Economics of Alaskan exploration

By K. MARSHALL FAGIN, *Field Editor*

THE fourth year of the Navy's oil prospecting activities in its 35,000 sq mi reserve in northern Alaska is marked now by the disappearance of the sun below the horizon and the beginning of another subzero Arctic winter night. The work of five geological and three geophysical field parties has been discontinued for the 1947 season. Drilling activity at the two rotary rigs, Cape Simpson No. 1 and Umiat No. 2, is being conducted with the aid of plywood enclosures and oil field boiler heating plants.

EXCLUSIVE

Ice, snow, and dangerous blinding blizzards are limiting all outside activities to a minimum. Radio-guided planes and weasels can operate throughout most of the Arctic winter, but heavy tractors must be driven cautiously in most areas until the ice becomes thick enough (about 50 in.) to prevent accidental break-throughs into lakes, rivers, or ponds.

Although only 12 to 15 in. of snow falls in this northern Alaska area during October, November, and December, it remains dry and powdery, so that every squall is apt to pick up and produce a blinding blizzard. It is this characteristic and not the volume of snow that makes it dangerous for men to work very far from shelter or travel without heavy Arctic clothing and a compass.

Aside from the important data that are being obtained on the oil prospects of Naval Petroleum Reserve No. 4, the Navy is learning extremely valuable lessons about ways of moving men and heavy equipment across the "Arctic crossroads of the World" in airplanes, tractor trains, boats, amphibious craft, and weasels. The Arctic experiences are being recorded and studied carefully and systematically, and these results alone may easily save our nation many times as much money, men, and material, as is being spent in this pioneering development.

● **The initial cost of prospecting for oil in Alaska.** Under the general supervision of the Director of Naval Petroleum Reserves, the initial expenditures in the search for oil in NPR-4 were made by the Navy's Seabees in 1944 and 1945 under the direction of Admiral Ben Moreell, Captain Bart W. Gillespie, and others. The Navy's petroleum demand in the Pacific theater of World War II were tremendous, and it appeared that California's production of 850,000 bbl per day could not keep the demand supplied.

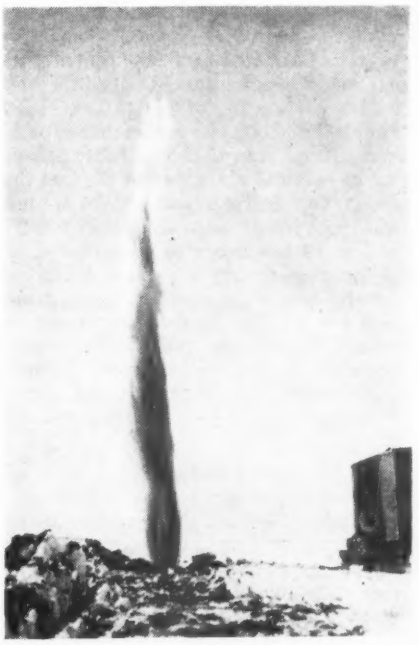
This grim outlook prompted the plans to explore and develop oil fields in NPR-4 as soon as possible. Well qualified, experienced, petroleum consultants were retained to guide the exploration as prudently as possible, so that mistakes made in the Army's development at Canol would not be repeated.

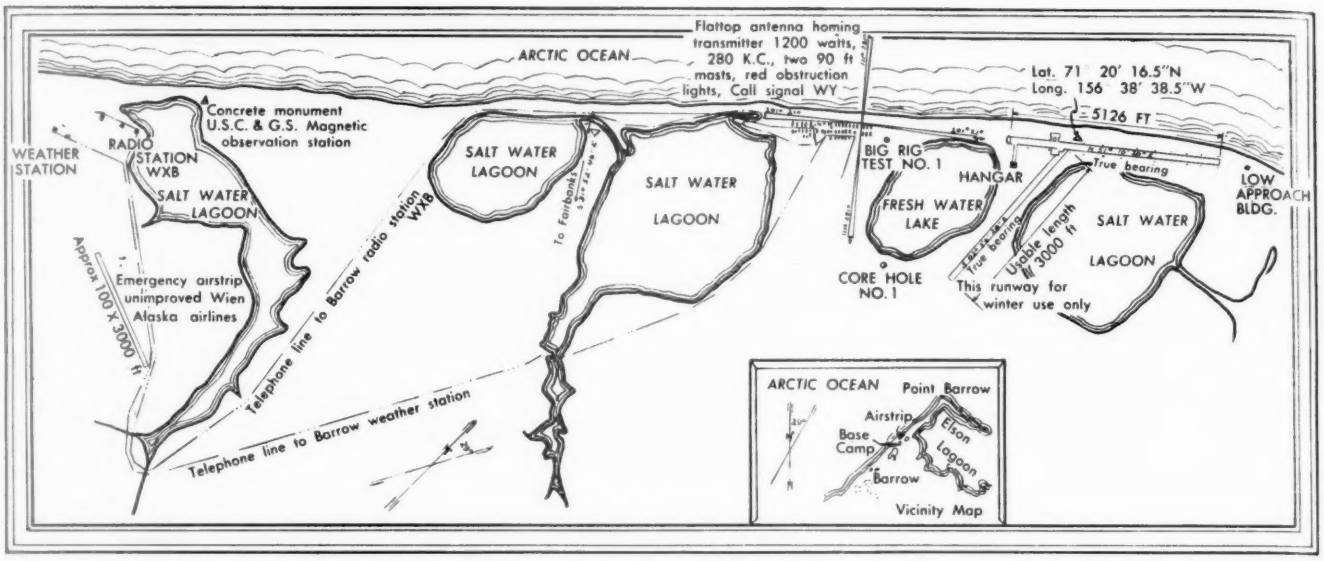
The exact amount of money spent by the Seabees in the initial stages of this exploration is not available to the writer, but it probably did not exceed $3,000,000 for building the base and airstrip at Point Barrow, preliminary geological and geophysical work, transporting drilling and camp equipment to Umiat, and drilling Umiat No. 1 to a depth of 1816 ft on September 16, 1945, when work was suspended.

● **Exploration continued to June 1950.** Oil shows found in Umiat No. 1, the large anticlinal structures discovered in the rolling hill country on the south part of the reserve, and the numerous oil and gas seeps in the Cape Simpson, Smith Bay, and Fish Creek areas in the northern part encouraged Congress to approve a Navy appropriation of $9,600,000 for continuation of the explorations until June 30, 1950.

About $5,200,000 of the appropriation

The instruments of a seismograph party will record the shock waves produced by this blast in a shot hole. The record will be ready for interpretation within three minutes after the shot was fired.





The Navy's base on the shore of the Arctic Ocean in Naval Petroleum Reserve No. 4 is situated southwest of the main air strip. It is about five miles northeast of the Eskimo village at Barrow and six miles southwest of Point Barrow as indicated on the inset map. The fresh water lake is deep enough to supply an ample quantity of water to the camp throughout the year.

has been spent for the 1946 and 1947 operations. The inventory of equipment and supplies that will be used in the 1948 season before the ships arrive again at Point Barrow next August represents about $1,000,000 more. The 1946 operations required about $2,000,000, and the 1947 operations cost about $2,800,000. Inventory purchases in 1947 for the 1948 program accounted for the $400,000 difference between $4,800,000 and $5,200,000.

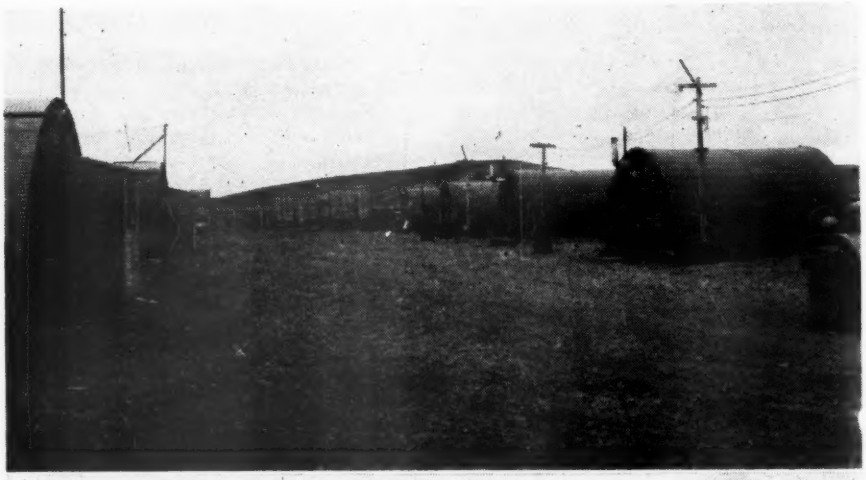
Contract and non-contract obligations for the balance of the program to June 1, 1950, amounts to about $1,000,000. This includes about $400,000 more for air support by Wein-Alaska, $150,000 more for USGS exploration and geological laboratory support, and $450,000 for procurement of parts, materials, and supplies that will be used after 1947.

● **Withdrawal of Naval air support reduced amount of money for prospecting.** About $3,400,000 remains unexpended or unobligated out of the original appropriation of $9,600,000. This is about $1,000,000 less for further exploration and drilling than was contemplated in the original plans due to the fact that the Navy Air Transport service support was withdrawn and almost $1,000,000 had to be taken out of the original appropriation to pay a private contractor for the necessary air freight and transport service. The loss of this money for actual exploration and drilling operations has forced the Navy and its operating committee to change and curtail their original prospecting plans.

The operating committee is now preparing a "short range" plan that will utilize the remaining funds in the original appropriation and close out the exploration contracts for June 30, 1950. It is also preparing a "long range" plan that will include projects with cost estimates to provide a basis for presentation to Congress to justify a request for addi-

Main street at Umiat base camp in July, 1947. Round-roofed buildings on left are covered with corrugated iron and equipped with plywood entrance shelters. The huts on the right are wood frames covered with layers of canvas. Insulation material between the canvas layers makes them inhabitable the year round.

A tractor equipped with a blade (bottom) attempts to dig a drainage ditch beside the melting road between Umiat No. 2 and the base camp near Umiat air strip in July, 1947. As soon as a section of road is drained, a thick layer of gravel will be used to insulate the frozen earth and prevent it from melting deeper.



AXELSON

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

Axelson pumps have a pleasant habit of surprising producers—by giving economical service far beyond reasonable expectations.

Many producers are also surprised to find that all Jones & Laughlin Supply stores stock Axelson repair parts. In addition, many stores have pump repair shops equipped with special time saving tools and manned by trained experts.

Never junk an Axelson Pump. Take it to your Jones & Laughlin Supply store. Have it put back in "like-new" condition. Enjoy the economical service only an Axelson gives.

Export: 230 Park Avenue, New York 17, N. Y., U. S. A.

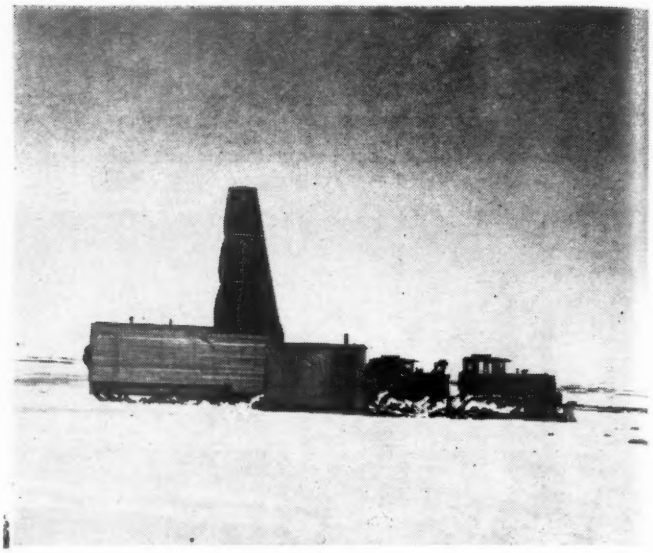
JONES & LAUGHLIN SUPPLY COMPANY

Subsidiary of Jones & Laughlin Steel Corporation

J&L STEEL

TULSA, OKLAHOMA

A seismograph party's "shooter" places a fuse in a charge of explosive he has prepared for the next shot. Two other sections of the charge are standing beside him against the sled-mounted shooter's house. Water is delivered through the rubber hose from tanks inside the house to tamp the shots before they are fired in a shot hole previously drilled near this scene.



A sled-mounted shot hole drilling rig is drawn across the snow-covered Arctic prairies and marshes by tractors in the subzero "Springtime" of March, 1947. Seismograph parties can work and move rapidly over the frozen marsh country that borders the Arctic Ocean for scores of miles inland.

tional funds to continue normal explorations in NPR-4 after June 30, 1950.

● **Navy has pioneered and obtained results with limited funds.** When one considers the huge investments that private U. S. oil companies often make in foreign lands before oil is discovered in commercial quantities, the Navy, its operating committee, its petroleum consultants, and especially its Director of Naval Petroleum Reserves, Commodore William G. Greenman, deserve considerable credit for the business-like way they have conducted the petroleum exploration in NPR-4. The weather, the uninhabited, roadless, swampy, lake-covered wilderness, and the difficulties of obtaining and moving men and materials over this large reserve have been conquered by the employment of modern airplanes, radios, and tractor-type vehicles. The Navy has pioneered in prospecting for oil in the treeless Arctic wastes of the large Barrow Basin and compiled a great deal of information about the structures and stratigraphy of this promising oil province with a limited amount of money.

A small, shallow oil well has been completed on the Umiat structure at Umiat Core Test No. 1, and minor gas shows have been found in Cape Simpson No. 1, which was drilling in hard shale at 5596 ft on October 18, 1947. Umiat No. 2 was drilling in silty shale at 4650 ft on the same date. Other structures have been detailed by seismograph during the 1947 season, so that test wells can be planned for the 1948 drilling program on these other known geophysical and geological highs.

The Navy and its operating committee has avoided drilling test wells on structures that are not well defined by modern scientific methods. Great thicknesses of sedimentary rocks in the Barrow Basin may produce large quantities of oil and gas from some of the structures found by the Navy. There are few, if any, bigger or more promising basins in the Western Hemisphere remaining for the development of petroleum production.

● **Large investment in base camps and materials.** Although it is difficult to determine exactly how much has been invested in the "logistic support" necessary to shelter, power, and supply the Navy's oil prospecting, it is evident that a large part of the money expended thus far has been invested in bases, machinery, and supplies that will be useful for many more years of exploration and drilling. The largest base is constructed along the black gravel shore of the Arctic Ocean between Barrow Village and Point Barrow (See Fig. 1).

This advanced headquarters base contains about 50 rounded-roof corrugated-iron-covered buildings. Twelve or more are 100-ft by 41½-ft warehouse and shop buildings. About 30 are 50-ft by 20-ft

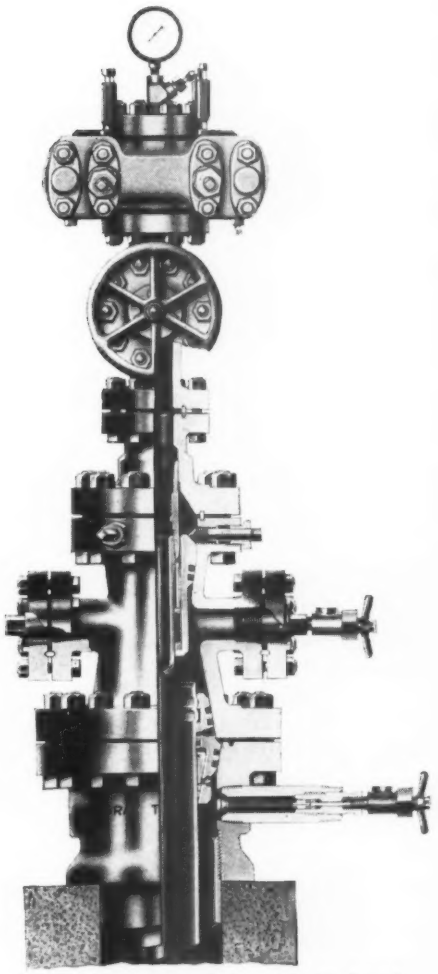
Umiat No. 2 was spudded in about 2 weeks before this picture was taken on July 3, 1947. Electric power for the rig and drilling camp is supplied by a diesel engine-generator unit in the building attached to the plywood boilerhouse.

PLANS AND SPECIFICATIONS

Coordinating fine individual parts into a planned system of operation

The GRAY name on a system of well control assures the operator that all parts of the job have been analyzed, and the system coordinated into a unitary whole. It means fewer parts of higher quality, more strength with less weight, and greater value at less cost. The ability to plan a given procedure and then put the plan into operation to satisfy a problem comes with experience. The desired results are obtained through the coordination of numerous parts into a planned system of operation. No miscellaneous group of individually strong parts can possibly approach the operating efficiency, economy and strength of equipment that is designed from the start to work as a unitary whole.

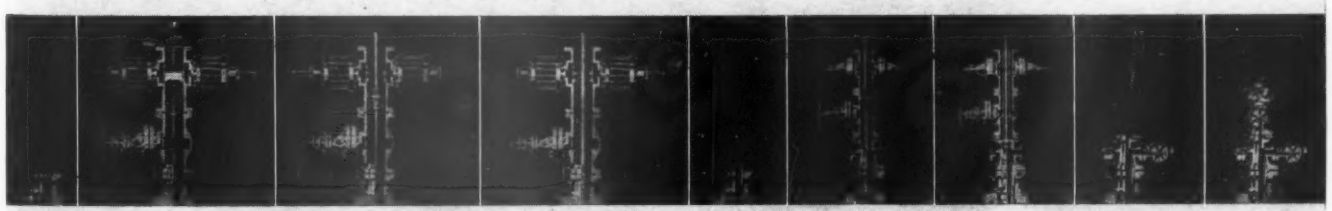
Gray Systems of Well Control are completely planned and coordinated methods of operation. These systems are on the job around the world, shouldering the problems of men who have to work in well control. Knowledge gained from problems solved with men who actually drill oil wells is available to you when you use Gray Systems of Well Control.



Complete Well Head Assembly Equipped with Composite Manifold, Valve Removal, Installation and Renewal.

GRAY TOOL COMPANY
HOUSTON

Export Representative: GUY E. DANIELS, 30 Rockefeller Plaza, New York City
Rocky Mountain Representative: CARL MOULDEN, P. O. Box 1890, Casper, Wyoming



Casing Head Attached | Drilling | Running Casing | Casing Landed | Drilling Control Equipment Removed | Drilling-in and Running Tubing | Tubing Landed | Control Equipment Removed | Manifold Attached

buildings for living quarters. Eight men can be accommodated comfortably in partitioned rooms in these buildings.

Other buildings of various dimensions include a diesel-electric power house, a moving picture theater, an administration building, a refrigerator house, a mess hall and galley, a bath house, a laundry and boiler house, a dry cleaning plant, a radio and weather house, an engineering and geophysical office building and shop, a riggers loft, a recreation hall. a hospital, and auxiliary buildings.

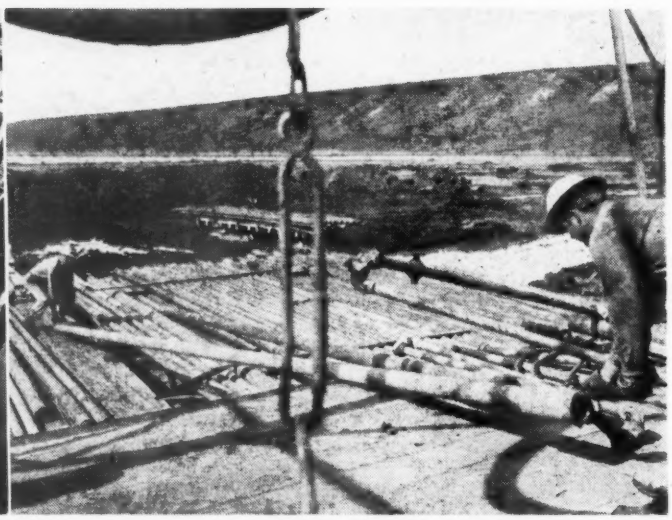
Much material and equipment is stored in yards and on racks around the

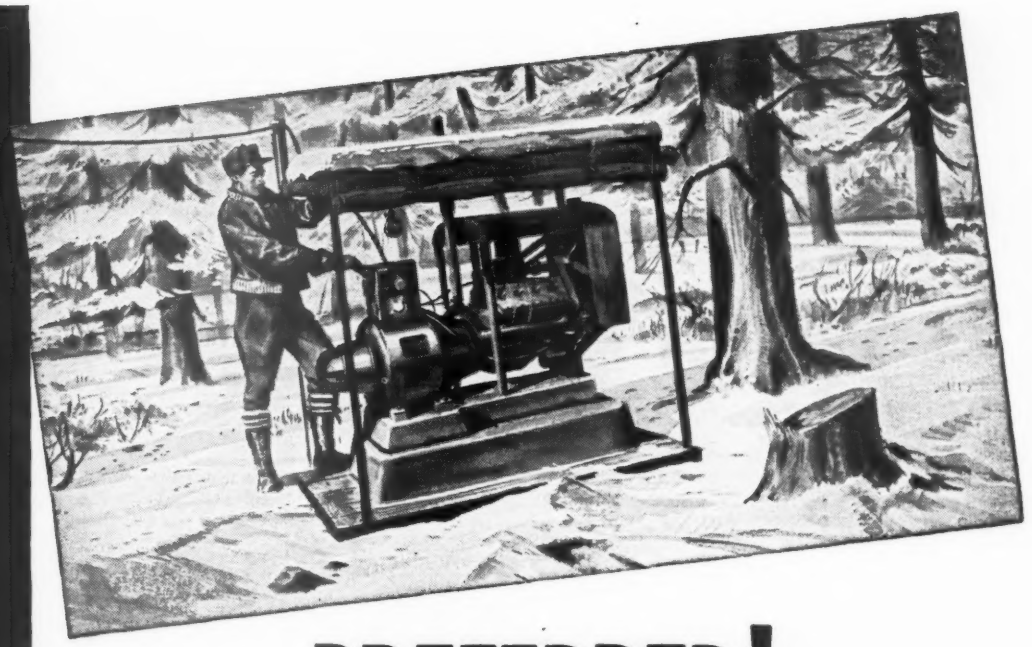
Officials discuss the Navy's prospects (top) on the leeward side of the diesel engines used in drilling Umiat No. 2. The men visiting the rig on July 3, 1947, include: (L to R) Quentin Singewald and Dr. George Gates, U.S.G.S.: Glen Ruby of Hoover, Curtice and Ruby; Walter English (rear), chief technical adviser; Bart W. Gillespie, project manager for Arctic Contractors; Cdr. P. W. Roberts, U. S. Navy; Commodore Wm. G. Greenman, director Naval Petroleum Reserves, and Leslie Riggins, geologist for Umiat No. 2.

Driller at Umiat No. 2 (center) feeds off wire line from the hoisting drum as the rotary drill digs through the upper part of the permafrost, permanently frozen ground, which is more than 900 ft thick in this area.

Drilling mud from Umiat No. 2 (bottom left) circulates through these wood flumes, over a shale shaker screen vibrated by an electric motor, and on into the mixing pits. The July, 1947, sun has turned the surrounding land into a quagmire.

Workmen tally another joint of drill pipe (bottom right) to be added to the string being used in Umiat No. 2. Water is obtained from Ox-Bow lake beneath the Colville River bluff in the distance.





PREFERRED!

—for RELIABILITY . . . for ECONOMY . . . and for UNIVERSAL FORD SERVICE!

Whether you *design* and *build* engine-powered industrial equipment, *sell* it, or *use* it, here is a fact so vital that it deserves your most earnest attention:

Nearly all such machinery—whether pumps, electric generating plants, compressors, power units, saw rigs, ventilating and spraying units, or other portable equipment—by its very nature, will spend its service life on jobs where it's "on its own"—where reliability and ready maintenance service are all-important—and where the transportation of motor fuel makes gasoline economy a constant concern.

FORD-BUILT ENGINES PROVIDE UNIQUE ADVANTAGES IN SUCH SERVICE. Ford engine reliability is known and respected the world over. Millions of Ford vehicle owners and automotive mechanics are thoroughly familiar with Ford engines. Ford economy is famous. And Authorized Ford Service is available in every community of any importance.

Certainly, then, if your power requirements come within the range of 40 to 100 horsepower, you could not choose an engine which would offer you as many positive advantages as Ford.

Three Ford-built engines are now available, as shown below. You can buy them singly or in quantity, through any Ford Dealer or from Ford Motor Company. For detailed specifications and dimensional data, write—

FORD MOTOR COMPANY

Industrial and Marine Engine Department

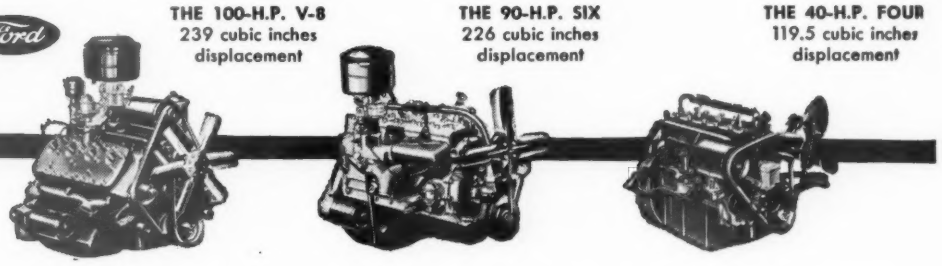
3505 SCHAEFER ROAD, DEARBORN, MICHIGAN

Ford

THE 100-H.P. V-8
239 cubic inches displacement

THE 90-H.P. SIX
226 cubic inches displacement

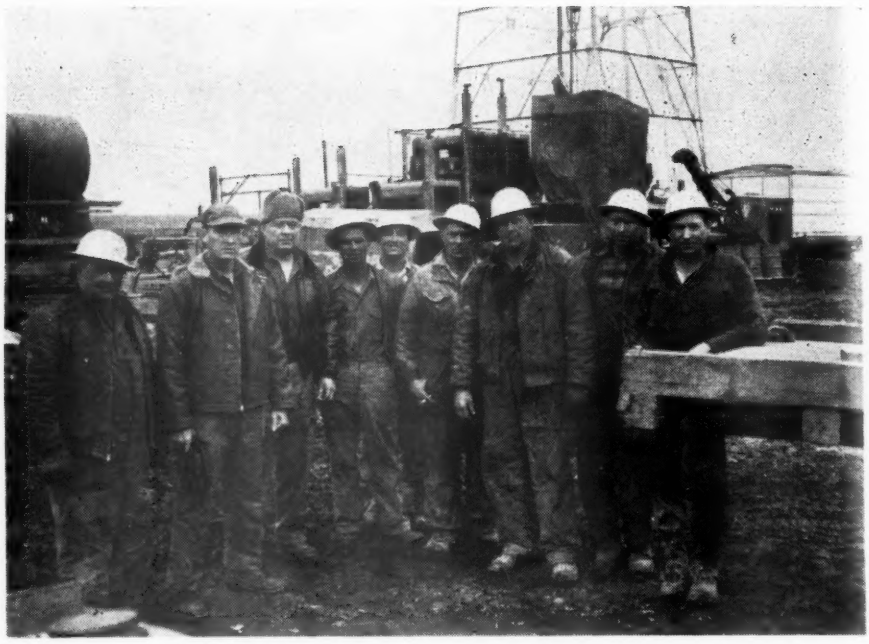
THE 40-H.P. FOUR
119.5 cubic inches displacement



FORD-BUILT ENGINES

FOR INDUSTRIAL AND MARINE POWER

Some of the men who operate the rig at Umiat No. 2 are: Warren Newell; Ralph Coleman, Chief Petroleum Engineer, and Bart W. Gillespie, Project Manager for Arctic Contractors; Joe Stroud, toolpusher; Bob Blodgett; Forest Garner; Tom Rooney, driller; Lloyd Terry, and Frank Biggs.



various warehouses and shops. Almost all of it was in good order and ready to serve in the task of supplying the geophysical and drilling operations being conducted in the Reserve when the writer was there last summer. In fact, there seemed to be enough basic support at Barrow Base to supply several times as much prospecting and drilling as was being done.

● **Base at Umiat being utilized fully.** The base at Umiat is much smaller than the one at Barrow, and it serves as the central inland crossroads of drilling and geophysical operations. It contained 18 buildings last summer. Five were 20-ft by 50-ft rounded-roof corrugated iron buildings. Four were 12-ft by 24-ft rounded-roof canvas-covered huts. The others were frame buildings of various sizes and construction and equipped for the following purposes: washhouse and showers, woodshop, warehouse, bunkhouse, engine repair house, power generating house, weather station, and garage.

About 50 men could be accommodated by the facilities at this base, and it was being used to capacity by the various skilled workmen, geologists, radio operators, airmen, and others involved in supervising the drilling and exploration operations in the southern part of the 35,000 sq mi Reserve.

Eight canvas-covered huts were erected at each of the two drilling wells. Cape Simpson No. 1 and Umiat No. 2. These huts served as quarters for the 24 men that operated the rigs, mess halls, radio sets, and other equipment at the well sites.

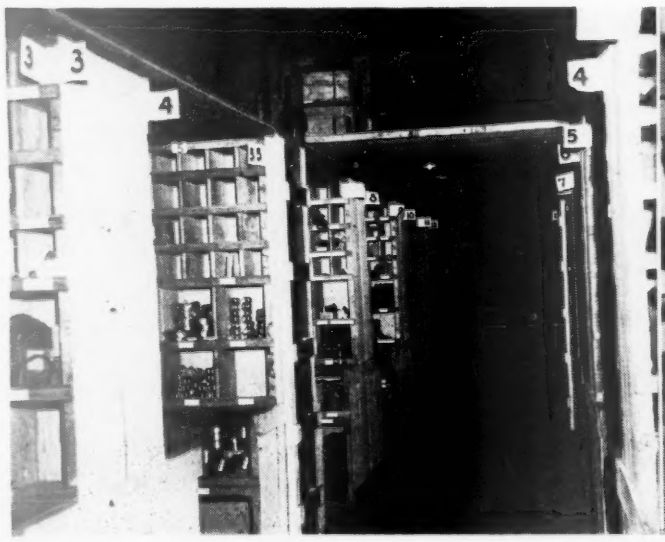
The two geophysical parties and core test crews are quartered in wanigans, small frame buildings mounted on steel pipe runners. These portable camps were described in **The Petroleum Engineer**, September, 1947, page 150.

● **Importance of Navy's operations in NPR-4.** Now that so many promising structures and great thicknesses of petroliferous sediments have been found in the huge Barrow geosyncline, it would seem prudent to continue the Navy's operations in a normal manner until the present base facilities and prospecting equipment are expended or oil is discovered in sufficient quantity to warrant expansion of the program and full development of such petroleum resources.

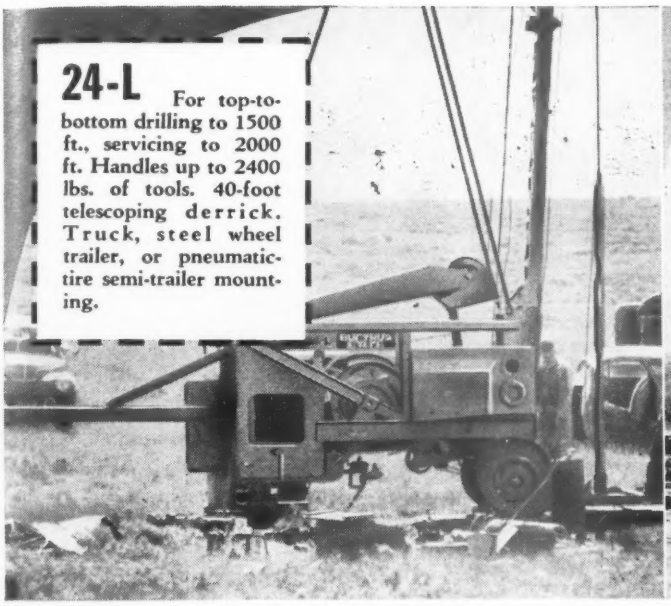
In fact, the writer believes that the present base facilities and auxiliary equipment are ample to support several times as much test well drilling and geophysical work as was being done last summer. By putting two or three more big rigs to work on other structures in the Reserve and adding more geophysical parties, the petroleum potentialities could be tested faster, and the "overhead" of supplying basic support might be cut in half. Expansion of the program would cost more per year, but it would take fewer years to explore the Reserve and develop its promising possibilities. Big rigs should be used to drill the test wells to 10,000 ft or the basement rocks, especially on large well-defined structures.

Should Congress decide to drop the present prospecting program in the in-

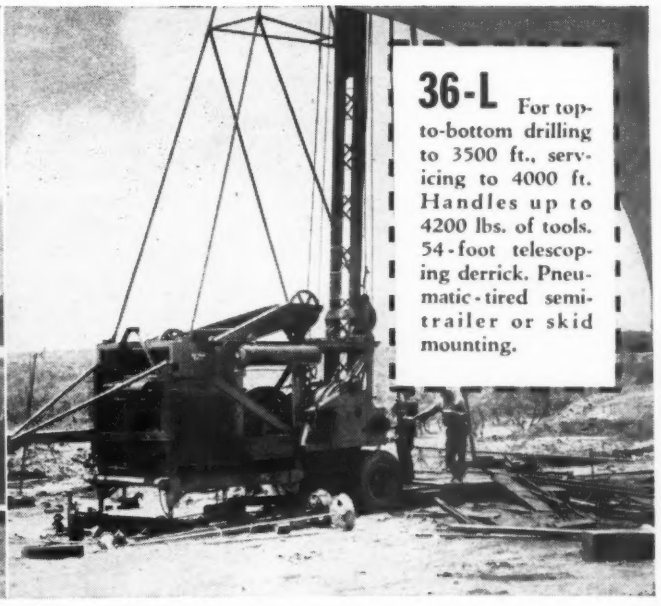
Thousands of spare parts for tractors, draglines, weasels, diesel engines, electric motors, generators, and other equipment are stored systematically in this warehouse at the Barrow base.



Radio operator in the advanced headquarters office at Barrow receives reports and transmits instructions to the drilling wells and geophysical parties every evening about 7 P.M. Contact is also maintained with all other operations on the Reserve.



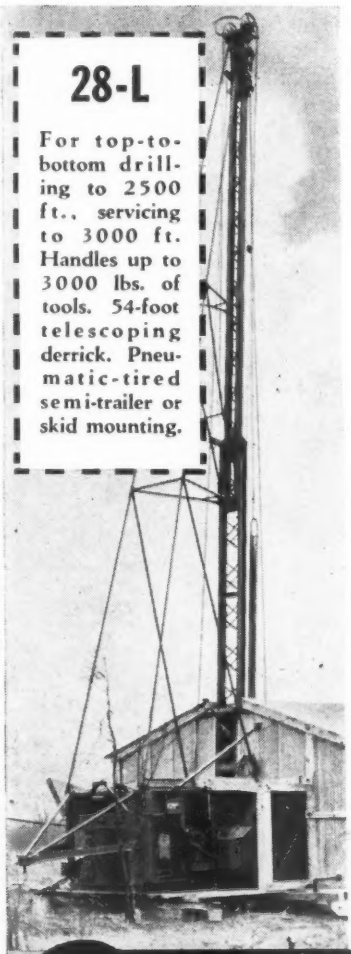
24-L For top-to-bottom drilling to 1500 ft., servicing to 2000 ft. Handles up to 2400 lbs. of tools. 40-foot telescoping derrick. Truck, steel wheel trailer, or pneumatic-tire semi-trailer mounting.



36-L For top-to-bottom drilling to 3500 ft., servicing to 4000 ft. Handles up to 4200 lbs. of tools. 54-foot telescoping derrick. Pneumatic-tired semi-trailer or skid mounting.

If It's a Bucyrus-Erie

IT'S THE SPUDDER YOU NEED



28-L

For top-to-bottom drilling to 2500 ft., servicing to 3000 ft. Handles up to 3000 lbs. of tools. 54-foot telescoping derrick. Pneumatic-tired semi-trailer or skid mounting.

Whether you specialize in top-to-bottom drilling, in servicing operations, or handle both . . . whether your work is at 1000 ft., 7000 ft., or in between . . . the spudder that can give you the service you want is a Bucyrus-Erie — a rig that has proved itself thoroughly in field performance. From the 24-L on up to the big new 48-L, Bucyrus-Erie spudders are easy to move over the road or on location . . . are simple to rig up, operate, or maintain . . . have the durable strength to keep up a fast steady pace . . . and the versatility for handling a wide range of drilling and servicing operations.

Incorporating designs developed by the largest skilled engineering staff among builders of cable tool drilling machinery, these machines feature all-steel, all-electric welded construction; easily erected telescoping derricks; truck, trailer, and skid mountings; two forward speeds and one reverse on all drums.

Look over the condensed specifications shown on this page to find the model that fits your depth and capacity requirements. Then ask your Bucyrus-Erie distributor—or write direct—for additional information.

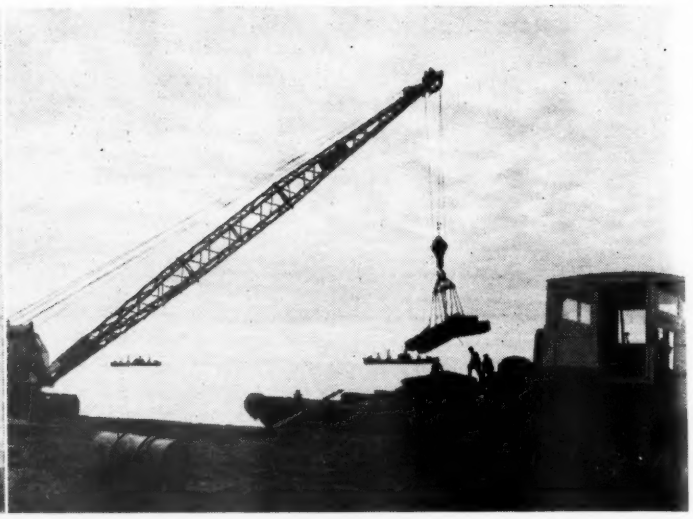
48-L

For top-to-bottom drilling to 6000 ft., servicing to 7000 ft. Handles up to 6000 lbs. of tools. 60-foot telescoping derrick. Pneumatic-tired semi-trailer or skid mounting.

BUCYRUS-ERIE COMPANY

South Milwaukee, Wisconsin

The landing barges (at left) work 24 hr a day to unload the ships that bring next year's supplies to the advanced base at Barrow when the Arctic Ocean ice melts in August.



Draglines are used to transfer equipment and supplies from the landing barges to storage on the beaches. Two of the four 1946 supply ships lie at anchor in the distance.

terest of governmental economy or for other reasons, it is probable that several oil companies would be interested in continuing the program, if satisfactory working agreements could be obtained.

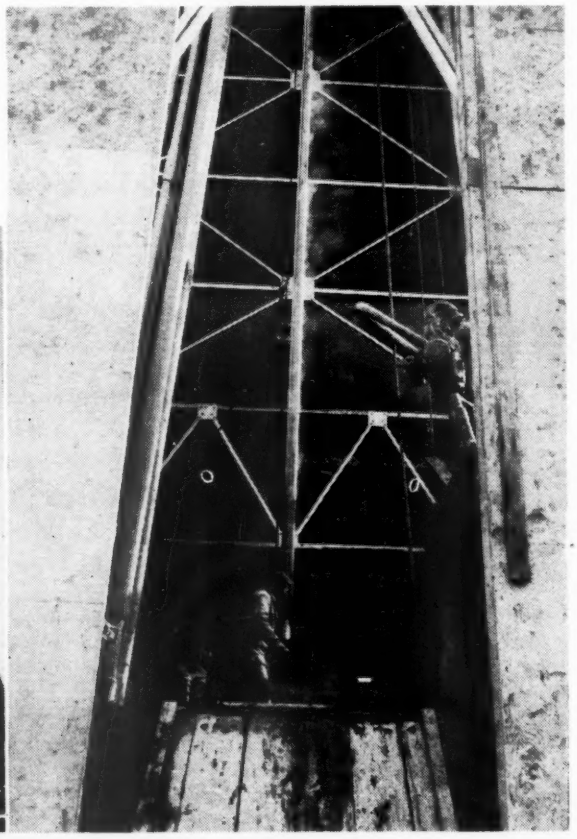
● **NPR-4 does not include all the area favorable for petroleum.** A large part of the Barrow Basin is not included in the 35,000 sq mi area set aside by President Harding in 1923 as Naval Petroleum Reserve No. 4. Thousands of square miles east and southeast of the Colville River, the eastern boundary of NPR-4, are considered favorable for the discovery of large oil and gas fields. USGS parties worked in the Canning River area last summer and reported the discovery of oil-bearing sedimentary rocks. Aerial magnetometer surveys were likewise favorable.

All North Alaska was closed to petroleum prospecting by private companies by an order of the Department of the Interior that was issued during World War II. Now that the war is over, this order might be rescinded. Such a change might attract private companies into this area and enable them to explore and develop commercially attractive petroleum production.

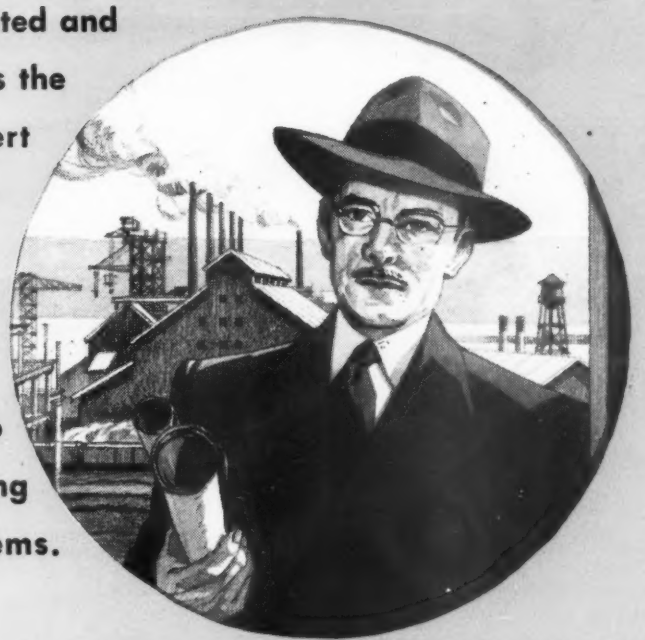
Data developed by the Navy, the USGS, and others make this area much more attractive now than ever before, and it is possible that arrangements could be made with the Navy for use of some of the facilities at Barrow Base, if needed by the private companies while their search is conducted.

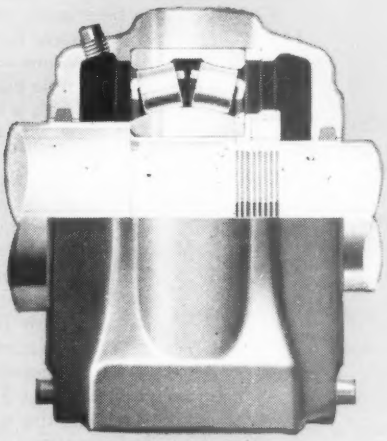
As it stands now, the Navy has so many prospects to explore on the Reserve itself that additional exploration and drilling by private companies in the areas outside the Reserve would advance the development of the petroleum resources of North Alaska by providing a

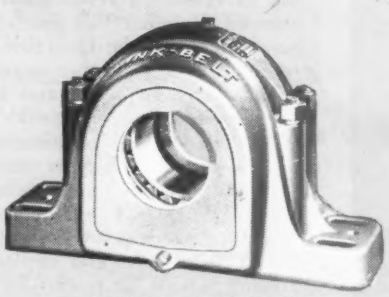
The drilling camp at Cape Simpson No. 1, about 40 miles southeast of Point Barrow (below), is a muddy place during the summer months of July and August, 1947. Looking through the keyhole (right) in the plywood enclosure around the derrick and drilling equipment at Cape Simpson No. 1 as the crew prepares to dump the bailer.



To claim long life—to claim efficiency—to claim accuracy for Link-Belt Ball and Roller Bearings is merely to accent the obvious. More interesting to you is the completeness of Link-Belt's Ball and Roller Bearing line—mounted and unmounted. Still more interesting is the nation-wide organization of expert Link-Belt Bearing Engineers, whose sole service to Link-Belt rests *in their service to you.* Use our books (No. 2094 and 2095 sent immediately upon request)... but use also the expert knowledge of our Bearing Engineers on your design problems.







1 Heavy series precision-built double row self-aligning roller bearings.

2 Inner ring directly mounted on precision turned or ground shafting assures greatest accuracy.

3 Locknut clamps assembly securely to shaft and is prevented from loosening by serrated lock washer.

4 Felt seals for grease lubrication or "Spiro-Seals" for oil or grease lubrication.

5 True flat surfaces assured for nut pressure surface.

6 Housings drilled and tapped for drain plugs on both sides.

7 Casting spotted for dowel holes to locate unit on support. Slotted holes for foundation bolts.

8 Sturdy, compact, split housing provides convenience in mounting, lubrication and disassembly.

9 Tapped holes in cap take standard screw to raise cap off base without damage to finished surface.

10 Permits different methods of lubrication, such as grease, constant level oil or circulating oil.

11 Bearings can be fixed or floated axially. "C" spacers may be inserted or removed as required.

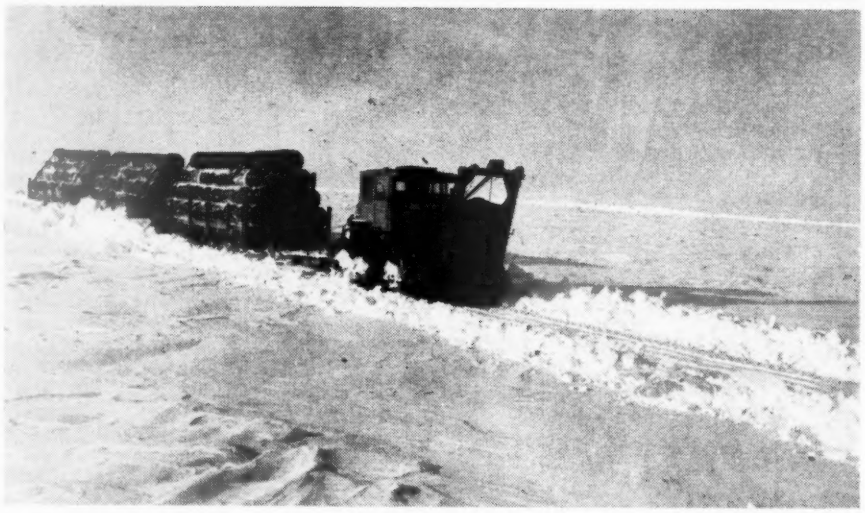
LINK-BELT COMPANY

Indianapolis 6 • Dallas 1 • Houston 2
Los Angeles 33 • Kansas City 6, Mo.
New York 7 • Toronto 8 • Offices, Factory Branch Stores and Distributors in Principal Cities.

LINK-BELT

BALL AND ROLLER BEARINGS

10,740-C



Workmen connecting a tractor to the wanigans of a "cat train" that transports heavy drilling and camp equipment over the frozen wastes of NPR-4 in February and March when the ice on the many lakes is more than 50 in. thick. The weasel serves as a command car to check route ahead of the trains. Fuel oil and gasoline for summer operations are carried in drums on sleds by this section of a "cat train." It is necessary for the sections to stay close together as blinding blizzards can be stirred up easily and quickly from the "dry" snow by sudden squalls of wind.

Lewis W. MacNaughton, consultant to the Secretary of the Navy and the Director of Naval Petroleum Reserves, on his annual survey of field operations at Point Barrow in summer of 1945. He is a member of the Navy's operating committee for NPR-4.

measure of competition. Important discoveries have been made in many areas that looked less favorable than the Barrow Basin.

● **Prospects for commercial production.** When as much as 500,000,000 bbl of crude oil reserves can be found in a field or fields in the Barrow Basin, a pipe line through the 2200-ft Anaktuvuk pass might be a feasible way of transporting the oil to a warm water port on the Pacific.

Preliminary aerial surveys have already been made of a possible pipe line route from Umiat, which is in the south central part of the Barrow Basin, to Fairbanks, which is about 350 miles. This was shown on Fig. 1 in the first article by the author in the August issue, page 44.

Estimates have been made that 100,000 bbl of crude per day could be transported from North Alaska to one of the warm water ports on the Pacific for 23 to 33 cents per bbl through such a line. Tankers could move it from there to the San Francisco area for 15 to 21 cents per bbl. It is not necessary to explain how important such a source of crude would be in augmenting production from the California fields.

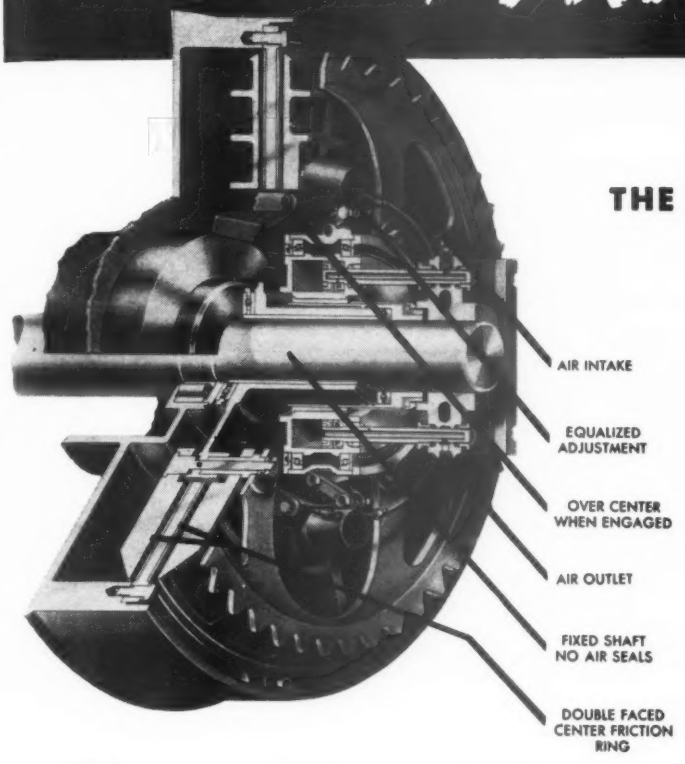
It is quite likely that this much daily production and crude oil reserves can be developed from the Barrow Basin prospects uncovered by the Navy's exploration program in this otherwise useless part of the world. It will take $75,000,000 to $100,000,000 to drill the wells, build the pipe line, and construct the marine terminal after as much as 500,000,000 bbl of crude oil reserve has been discovered. Whether this much oil can be produced from the favorable structures found so far, or whether more structures will have to be found and tested, is a question that may be answered in the next 2 to 7 years, by continuing the present program of drilling and scientific exploration. It should certainly be continued by the Navy on NPR-4 while so much useful equipment and supplies are already available, and exploration and drilling outside the reserve by private oil companies would hasten the day when commercial production is established.

A basin that contains as many millions of acres of favorable oil land as the Barrow Basin is bound to have commercial oil production as soon as it is adequately tested by the drill. ★★★

Announcing FRANKSAIR

THE LATEST IN AIR CLUTCHES

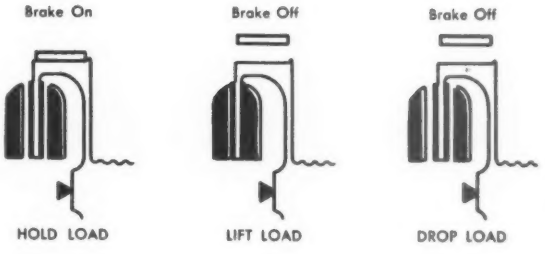
FOR SERVICING UNITS AND DRILLING RIGS



Franks, the pioneer of the final drum drive friction clutch for well servicing and drilling units, now offers the FRANKSAIR full air clutch. The FRANKSAIR has all the features of any air clutch plus "over-center" engagement or disengagement, lighter weight, and more drum capacity in less space features.

The FRANKSAIR (patent applied for) clutch affords smoother, more efficient operation. It is designed to give "finger tip" control, thus regulating gradual engagement or disengagement at the will of the operator. It provides not only a cushioned engagement, but also a positive separation of the clutch plates upon disengagement, thus assuring a free wheeling drum.

FRANKSAIR is another reason for investigating Franks servicing units and drilling rigs before you buy. See your favorite supply store, a Franks sales representative, or write the main office.



HOW CLUTCH-ACTUATOR MECHANISM WORKS

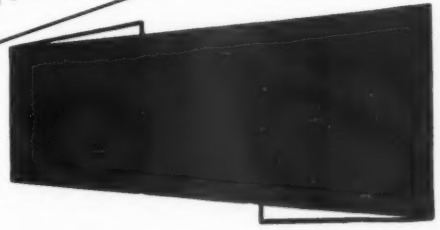
FRANKSAIR clutch-actuator mechanism is a device for positively engaging and disengaging a final-friction drive winch clutch by air pressure on a cylinder and piston incorporated into the clutch assembly. It is a movable annular cylinder upon a fixed shaft, which operates as a piston and valve arrangement actuated by air pressure introduced in either "in" or "out" chambers and engaging or disengaging the Franks double faced center friction ring clutch.

AVAILABLE FOR PRESENT FRANKS UNITS

FRANKSAIR type CLUTCH is available in a complete conversion package for most models in current use having the old style shifting mechanism. The change may be made at any Franks service branch.

CHECK THESE FEATURES

- GRADUAL ENGAGEMENT OR DISENGAGEMENT, feeding "ON" OR "OFF" at will of operator.
- SIMPLIFIED AND STREAMLINED by elimination of mechanical linkage, rotating air seals, and drilled shafts.
- EXCESSIVE HEAT ELIMINATED, as the air actuating mechanism is some distance from the area of clutch engagement.
- GREATER OVERALL FRICTION SURFACE provided by double-faced clutch.
- CLUTCH STAYS "IN" OR "OUT" INDEPENDENTLY of sustained air pressure.
- SINGLE POINT HYDRAULICALLY EQUALIZED ADJUSTMENT assures uniform clutch plate engagement.
- WIDER DRUM permitted by Franks Air Clutch placement, permitting greater capacity within 8' road limits.
- CONSTANT ENGAGEMENT CAPACITY, as this clutch, unlike others, is not affected by centrifugal force.



Main Office and Plant: Box 3218, Tulsa 8, Okla.

FRANKS DIVISION SALES OFFICES

Exclusive Export: A. V. Simonson, 149 Broadway, New York, N. Y.
Exclusive Pacific Coast: Hillman-Kelley, 1000 Macy Street, Los Angeles
Fort Worth: R. M. White, Neil P. Anderson Building, Phone 2-4241
Houston: S. E. Corry, 320 Bankers Mortgage Building, Phone Preston 2472

FRANKS SALES AND SERVICE BRANCHES

Kilgore, Texas: Albert Hastings, 1800 East Longview St., RR No. 1, Phone 597-J
Odessa, Texas: Kenneth Lamer, Box 689, 2316 Kermit Highway, Phone 3755
Great Bend, Kansas: Tommy Knoblock, Box 167, 10th & Lincoln, Phone 877
Mount Vernon, Illinois: Vern Alley, Box 33, Phone 1543-JX
Compton, California: George Lewis, 909 North Alameda St., Phone Newmark 2-4181

Application of internal-combustion engine power to rotary drilling rigs*

By W. S. CRAKE, Shell Oil Company

● **Introduction.** The conclusion of the war, and the gradual return to normal peacetime pursuits of industry has, in the oil industry, as in others, paved the way to improvement and redesign of methods and machinery toward better and more economical performance. The majority of machinery available today is of prewar vintage, which has been modified, as far as possible, and improved, within old basic design limitations.

Oil company and oil supply company engineers are forced, along with an extreme shortage of experienced personnel, to comb through, study, and try to adapt many warborn ideas to their operations and to pick up the strings of development that have been broken for the duration of the war. A number of interesting and informative technical articles have been published in recent months on power transmission methods for drilling operations. Most of these have been written largely from the viewpoint of the expert in power transmission, rather than from intimate knowledge of oil-field requirements.

The author, in this paper, offers a summary of the governing internal-combustion engined oil-well drilling requirements, load characteristics, load factors, the effect of these characteristics on the choice of prime movers, and also directly comparative characteristics of the three power transmission media currently available—mechanical, electrical, and hydraulic. Steam powered equipment is omitted from this discussion, although there is no inference that steam does not have its place in the industry for drilling operations, mainly where cheap fuel and good boiler water are both available.

It is hoped that this presentation will be of help to operators and machinery designers, particularly in arranging speed ratios that most nearly adapt themselves to proper usage of any of the three power transmissions desired by the operator.

Economical performance in the minimum of time is the end result the oil company requires. Simplicity of operation is desirable and ease of erection, moving, and dismantling is also important. In the writer's opinion, so long as it is reliable and rugged, the machine itself need not overstress simplicity. Modern efficient machines are inherently complicated and we users must learn to operate them in order to do our job properly.

● **Basic drilling load characteristics.** Before attempting to purchase or apply motive power to an oil-well drilling rig, an extremely thorough study of the load cycle, motion cycle, and operating habits is vitally necessary. Many failures of equipment to perform satisfactorily have been caused by the question "how much horsepower?" instead of "how is the horsepower used?" When attempting to use a new method of power application on a drilling hoist, this intimate knowledge is particularly essential in making the most of the characteristics of the new transmission in order to yield its best performance at the hook.

A. Hoisting. Fig. 1 shows a typical set of single load curves for "going in the hole" and "coming out of the hole." The "pickup" and "hoisting" peaks on either curve will vary from below full value in each gear, depending on the transmission method employed.

Fig. 2 shows typical hook loads and engine loads on the hoisting cycle with a mechanical transmission.

Table 1 gives some idea of the overall load factors that may be expected on drilling rigs of various classes. The values have been taken partially from actual field results and partially from interpolations. The figures were worked back from actual fuel consumption figures on a number of locations. They are, however, subject to relatively wide variations in each class, depending on whether the wells are "exploration" or "development" wells. In the latter cases, the load factors should decrease and on the former they will normally increase.

B. Drilling. Fig. 3 shows a typical buildup of load while drilling as the well progresses from start to full depth.

On internal-combustion engined rigs, in particular, the peak horsepower output of the engines is obviously the maximum obtainable from the rig. In fact, maximum drilling horsepower should be about 85 per cent of peak intermittent or "hoisting" horsepower unless engine trouble is to be expected. Peak horsepower can be employed for short periods only, when drilling, for this reason.

C. Auxiliaries. On most engine driven rigs, it is the common practice to rob power from the main engines to supply the majority of the normal auxiliary power. When a rig is operating at full load, the use of separately driven auxiliaries will increase the drilling capacity of the rig by making the auxiliary power, normally robbed from the engines, available for drilling use.

The tabulation in Table 2 is illustrative of the order of main power and auxiliary power requirements on an extra heavy rig.

*Presented before The American Society of Mechanical Engineers, Houston, Texas, October 5-8, 1947.

TABLE 1. Load factors for oil-well drilling.

Class of rig	Gulf Coast drilling				Hard rock drilling			
	Light	Medium	Heavy	Ex. heavy	Light	Medium	Heavy	Ex. heavy
Rig horsepower*	400	600	1,000	1,500	400	600	1,000	1,500
Drilling depth	5000	8000	10,000	12,000	6000	9000	11,000	15,000
Avg. load factor, per cent	45	43	33	28	35	31	27	23
Avg. hp load	180	258	330	420	140	186	270	345
Daily hp-hr	4320	6200	7920	10,200	3360	4430	6,480	8,300

*Assuming all this horsepower available for primary drilling service. Auxiliary service requirements are extra.

TABLE 2. Power services.

Main	Auxiliary
(i) Drilling	
a. Main slush pump	a. Lights
b. Rotary table	b. Washdown pump
c. Auxiliary slush pump (alternate to (a) when needed)	c. Mud screens
d. Mud mixing pump	d. Bug blower fans
	e. Air supply
	f. Blowout preventers
(ii) Hoisting	
a. Hoist	a. Lights
b. Rotary—breakout	b. Washdown pump
	c. Bug blower fans
	d. Air supply
	e. Blowout preventers
	f. Fill up pump

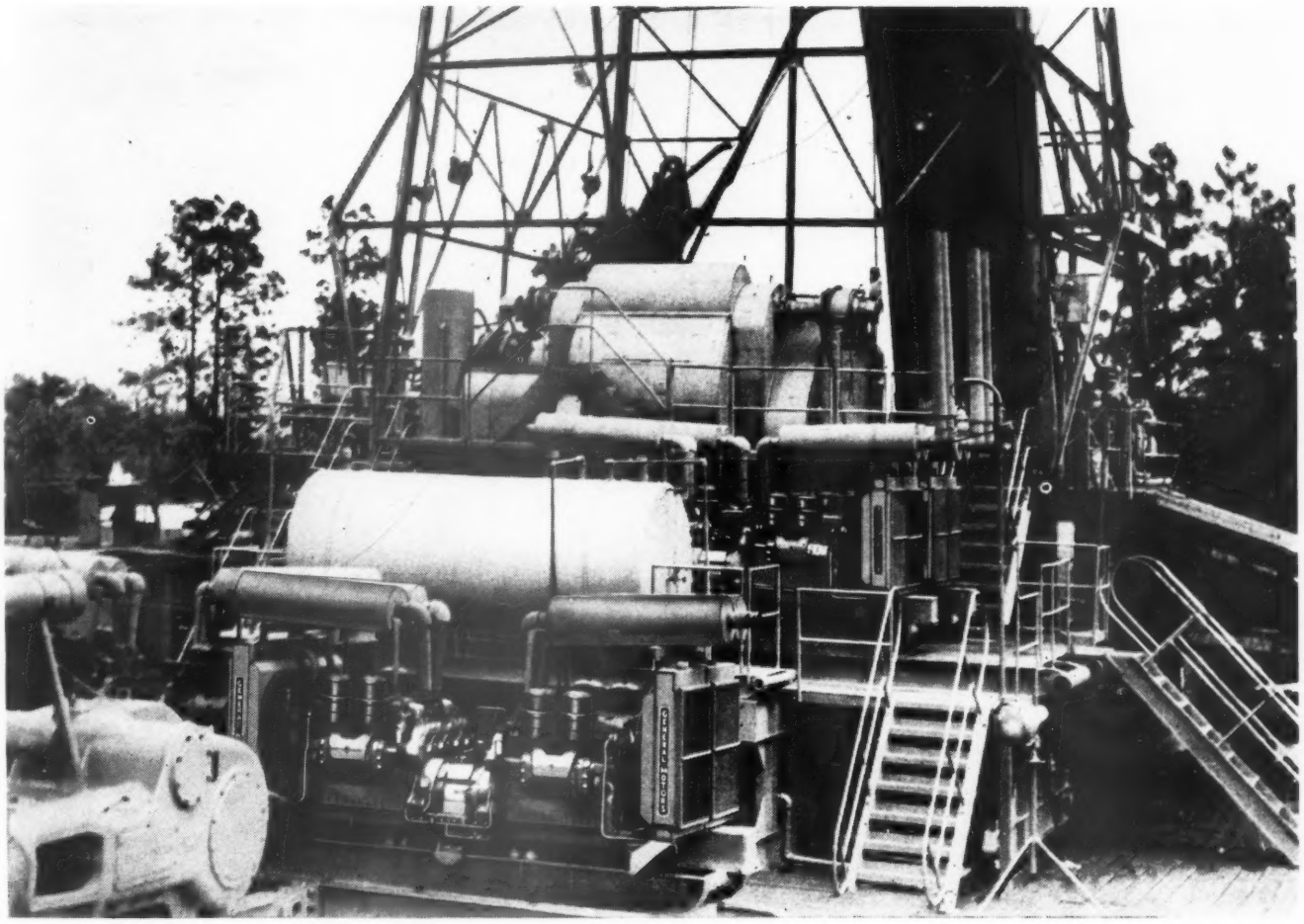
Approximate auxiliary horsepower required

Service	Hp
Lights, etc.	7½
Washdown pump	7½
Mud screens (2)	4
Bug blowers (2)	4
Air supply	5
Fill up pump, BOP pump	20
	48

Say, 60 hp available.

From Table 2 it can be seen that the total auxiliary power is in the neighborhood of 5 per cent. This excludes engine cooling fans, which are part of the engine and would bring the auxiliary power up to about 15 per cent of the total produced by the engines.

The auxiliaries would run simultane-



"Oilwell" No. 96, mechanical rig at Leesville, Louisiana, powered by four General Motors Series 71 Diesel "Quads."

Next Stop, 10 miles at sea

HERE you see what is most likely the highest-powered internal combustion driven oil rig in the world. Four General Motors Series 71 Diesel "Quads" give it 2080 husky continuous horsepower.

Right now it is drilling at about 11,000 feet. Soon it will start a new hole from a barge ten miles off the Louisiana coast.

That points up the feature of this flexible, dependable, convenient kind of power plant.

There's plenty of power in fewer units that weigh less and that take less space. That means greater portability and more hole drilled in shorter time.

All this is why you see more and more drilling machinery powered with these General Motors Diesels. You will want all the facts, so get in touch with us.

DETROIT DIESEL ENGINE DIVISION

DETROIT 28, MICH. ● { SINGLE ENGINES . . Up to 200 H. P. / MULTIPLE UNITS . . Up to 800 H. P.

GENERAL MOTORS

DIESEL BRAWN WITHOUT THE BULK

GM GENERAL MOTORS DIESEL POWER

GENERAL MOTORS CORPORATION

DIESEL ENGINE SALES, PETROLEUM INDUSTRY, 1504 PHILTOWER BUILDING, TULSA 3, OKLA.

ously sufficiently often that it should be assumed that they would be using power from the main engines for a considerable part of the day's run. There is, thus, little out of the ordinary in auxiliary load characteristics, but they must be considered and the most vital pieces of auxiliary equipment are usually supplied in duplicate.

● **Effect of load characteristics on choice of prime movers.** *A. Flexibility.* As can be seen from the hoisting portion of the load curve in Fig. 1, the load requires the most rapid possible application of accelerating torque and a horsepower delivery that mounts as rapidly as the load reaches full speed.

As no mechanical coupling methods, such as friction clutches, will stand the wear and tear of being thrown in against engines running at full speeds, some method of reducing these shock loads is vital on all drilling machinery. On direct mechanical drives, the only compromise is to connect the load with the engines running at about idling speed and then accelerate the engines. This does not produce any torque multiplication, but is capable of being withstood by clutches. For this reason, drilling rigs generally require engines with rapid acceleration characteristics and relatively light flywheels—automotive type performance—to obtain the desired acceleration and reduce maintenance costs on transmission members.

The use of slow speed, heavy duty engines has not, to the writer's knowledge, been successful in any field application for these reasons and the list of present day hoists are no exception to this statement. When using diesel engines, with their known flat torque curves, the shocks to transmission are doubly difficult to withstand.

B. Governors and flywheels. As mentioned above, all transmission methods require engines highly responsive of speed to load and light flywheels are, therefore, highly desirable. General practice is to use engine throttle controls with a maximum governed speed of the engine. All drilling loads are of the type that make the increasing of torque of automatic opening of the throttle by governors highly undesirable. If the torque raises at any throttle set point, the speed should drop accordingly. This is particularly the case when rotary tables are driven through speed reduction gears and where governor controlled engines may open up, unbeknown to the operator, and very easily cause drill pipe failures or "twistoffs."

The single exception to the above points is the use of heavy duty constant speed engines for electric drilling in which the load is coupled and accelerated, not through friction clutches but by electric motors. In this case, power input can be easily controlled by the operator. In view of the undesirable nature of running any engines on a drilling rig at full speed continuously and the primary requirement of portability, the writer feels that, even in this application, the light, flexible engine is desirable, along with some device that idles the engine when it is not required for full speed operation.

C. Load coupling. The most modern hoists tend toward complete friction clutch drives, both for speed changes and main load coupling. The actual load coupling unit varies with the various types of transmissions enumerated below. All types can best be operated by starting from near idling speed before coupling and by accelerating the load as the engine itself accelerates to the required power output speed.

● **Transmissions and their characteristics.** The following paragraphs are an attempt on the part of the author to give a direct comparison between the mechanical, electrical, and hydraulic methods of transmission, when properly applied to drilling hoists and other drilling machinery. The specific examples are chosen as being representative of transmission method and will show the hoist speed ratios and output torque speed characteristics on each of the three methods of drive. A 1000-hp hook load curve is shown, which is used as an example of a rig of about 1500-hp input.

In all the curves, a 1000-hp delivered power is assured, with some slight increase shown as the efficiency of the drive improves. As a matter of interest, and of considerable concern to users, the overall efficiency of the three methods are given in Table 3.

TABLE 3. Hook to engine shaft horsepower data.

	Per cent
a. **Mechanical efficiencies**	
Hook to drum	92
Drum to average engine	75
Overall	69
b. **Electrical efficiencies**	
Hook to drum	92
Drum to motor	90
Motor and cables	90
Generator	92
Overall	68.5
c. **Hydraulic efficiencies**	
Hook to drum	92
Drum to average engine	75
Torque converter, average	81.5
Overall	56.25

Horsepower data

	Engine shaft hp for 1000 hook hp	Hook hp for 1450 engine shaft hp
Mechanical	1450	1000
Electrical	1460	996
Hydraulic	1775	820

A. Mechanical. As is well known, mechanical transmissions give output torque characteristics that are, neglecting friction, in direct proportion to engine characteristics. Speed changes on

FIG. 1. Typical single-stand load curves.

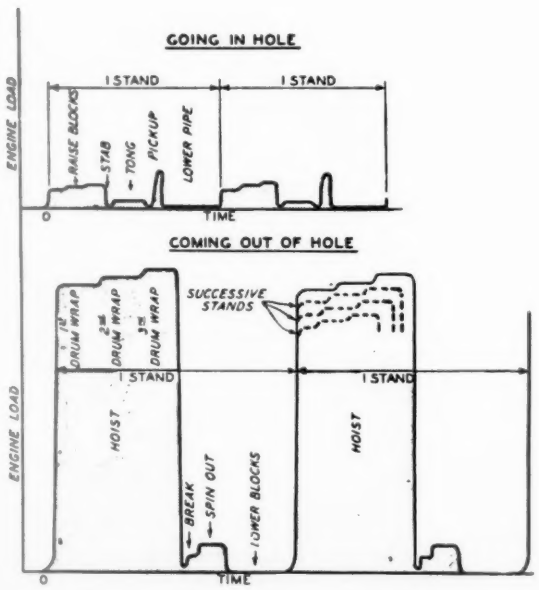
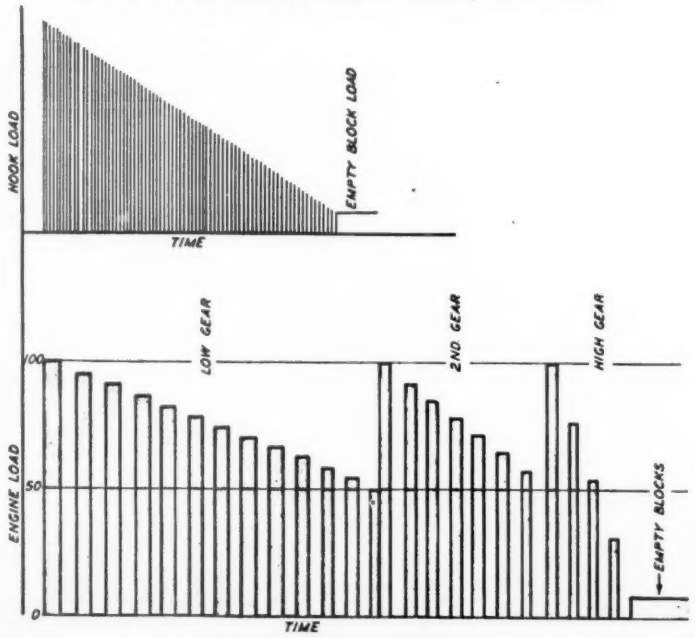
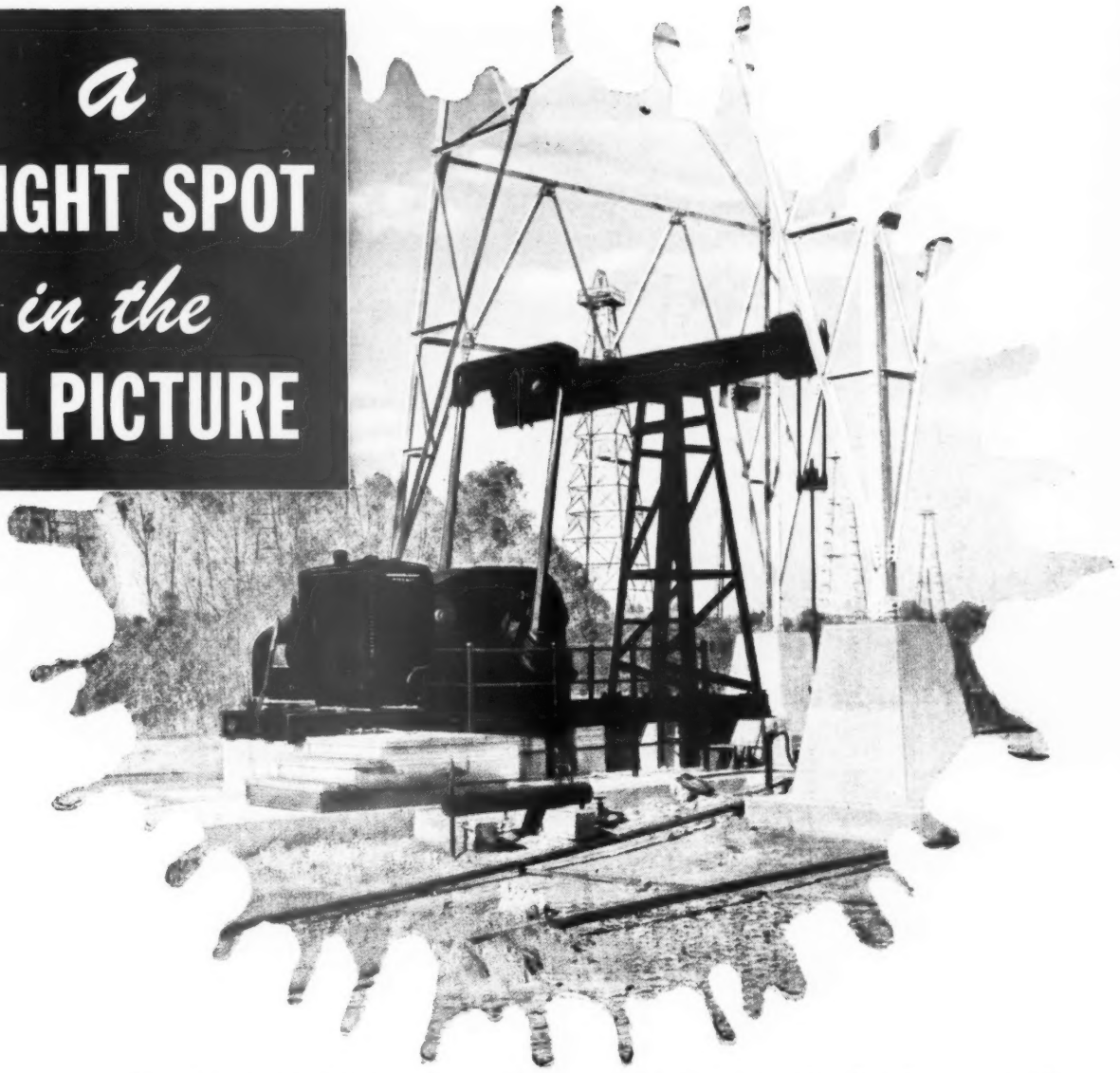


FIG. 2. Hook and engine loads coming out of hole.



a BRIGHT SPOT in the OIL PICTURE



There's no trouble at the well—with International Power Units converting waste gas into steady oil pumping output.

International four-cylinder, valve-in-head engines render yeoman service—with a minimum of maintenance—on either steady or intermittent pumping jobs.

The wells that are pumped by Internationals are, consequently, dependable producers. They keep a high level of crude at the head of the pipelines. This helps assure adequate supplies for the country's mounting needs.

Why not investigate the International line of power units adapted to your pumping requirements? Your International Industrial Power Distributor can give you all the facts, including specifications, performance data and the many features which distinguish them from other engines.

Industrial Power Division
INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue Chicago 1, Illinois

INTERNATIONAL *POWER*

CRAWLER AND WHEEL TRACTORS • DIESEL ENGINES • POWER UNITS

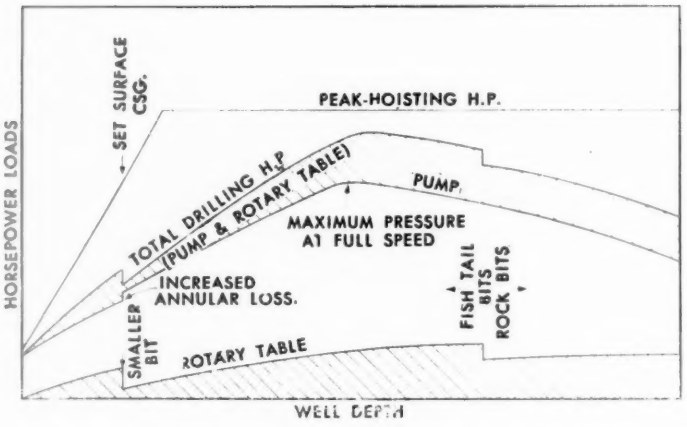


FIG. 3. Typical drilling well horsepower loads (one size of drill pipe).

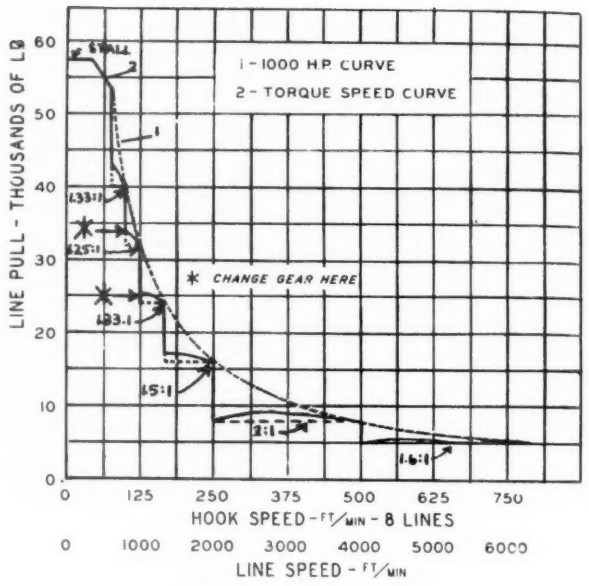

LINE PULL - THOUSANDS OF LB
1 - 1000 H.P. CURVE
2 - TORQUE SPEED CURVE
STALL
* CHANGE GEAR HERE
HOOK SPEED - FT/MIN - 8 LINES
LINE SPEED - FT/MIN

FIG. 4. Mechanical 6 speed curves.

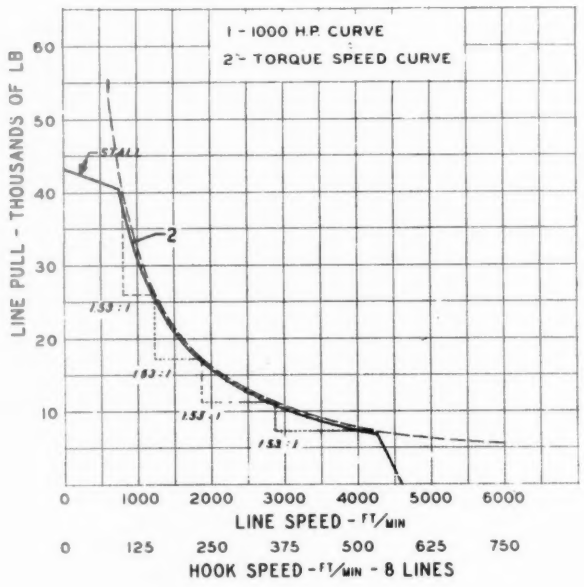


FIG. 5. Electrical 4 speed curves.

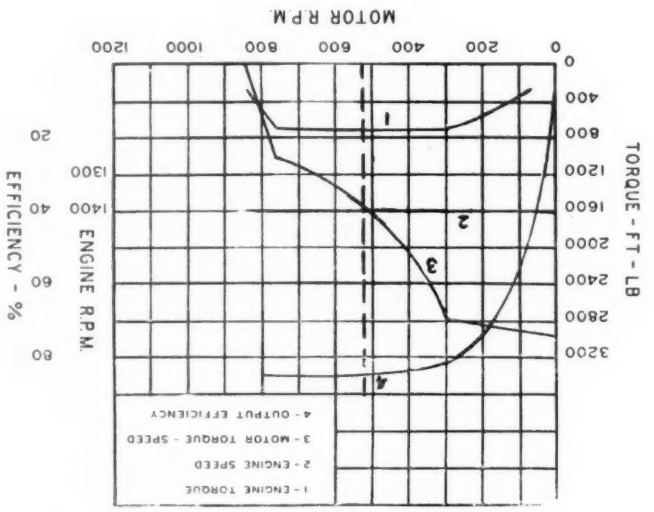


FIG. 6. Engine-electric motor characteristics.

decreasing loads are made after the engine reaches maximum governed speed and when engine loading has become reduced below the maximum by an amount inversely proportional to the next increase of speed ratio. When the speed ratio is decreased, the engine is once again loaded to full load at full speed and again falls off, step by step, as the load falls off. If, as is generally the case, the speed is changed too soon, the torque pulls the engine speed down toward peak torque speed of the engine, resulting in very slightly more torque but a greatly reduced speed. This gives a considerably reduced horsepower input to the machine. In either case, the engine reaches full horsepower at full speed at only one point of the load for each speed.

Fig. 4 illustrates the speed torque characteristic of a mechanically driven drilling hoist that has, for the sake of illustration, a 1000-hp maximum hook horsepower. It will be noticed that, in order to reach the peak pulling torque and speed necessary for the class of hoist chosen, it is necessary to employ six speed steps.

The main load steps chosen are equal load steps with a special ratio step shown on each end to obtain the high peak speeds and torque necessary for full performance.

The shaded areas under the curve represent loss of applied horsepower to the load because of the necessity to reduce engine speed, or load, to conform to the gear ratios. A greater number of speeds, naturally, would reduce the area of the losses.

All mechanical hoists use friction clutches for coupling the engines to the load. In some cases, hydraulic couplings are also employed to absorb torque shock loads. Hydraulic clutches are seldom used for actually coupling the loads because of the extreme variations in speeds required from a drilling hoist and the low efficiency of hydraulic couplings at low speeds.

The best of modern hoists employ friction clutches to a large degree for speed changes as well as for load coupling. Accelerating of loads is almost invariably performed by coupling the loads at reduced engine speeds and accelerating engines and load together. Most hoist clutches will not withstand the overload caused by impressing engine full speed inertias against the clutches.

As may be easily seen, the above statement is more true in the higher gears than in the lower gears because of the greater load inertia to be over-

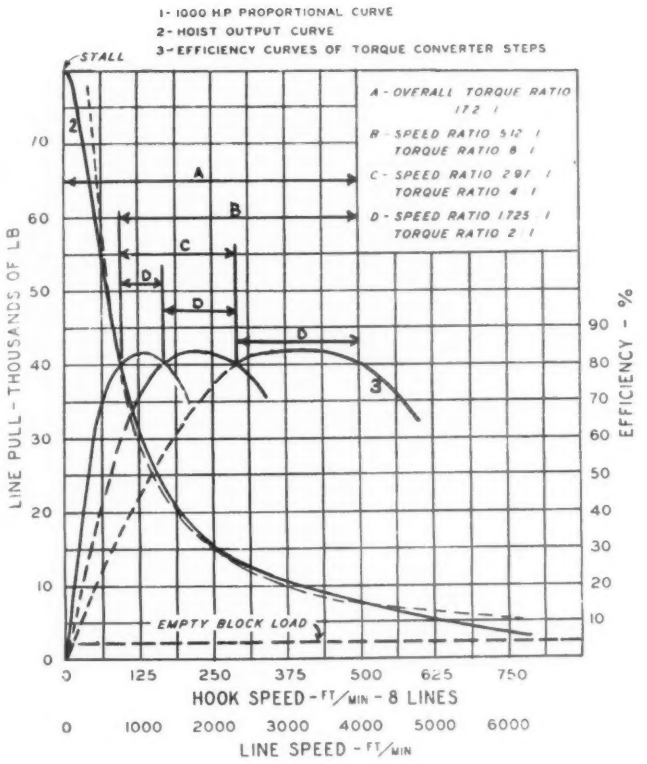

1- 1000 H.P PROPORTIONAL CURVE
2- HOIST OUTPUT CURVE
3- EFFICIENCY CURVES OF TORQUE CONVERTER STEPS
STALL
A - OVERALL TORQUE RATIO 17.2 :1
B - SPEED RATIO 5.12 :1 TORQUE RATIO 8 :1
C - SPEED RATIO 2.97 :1 TORQUE RATIO 4 :1
D - SPEED RATIO 1.725 :1 TORQUE RATIO 2 :1
EMPTY BLOCK LOAD
LINE PULL - THOUSANDS OF LB
EFFICIENCY - %
HOOK SPEED - FT/MIN - 8 LINES
LINE SPEED - FT/MIN

FIG. 7. Hydraulic 3 speed hoist.

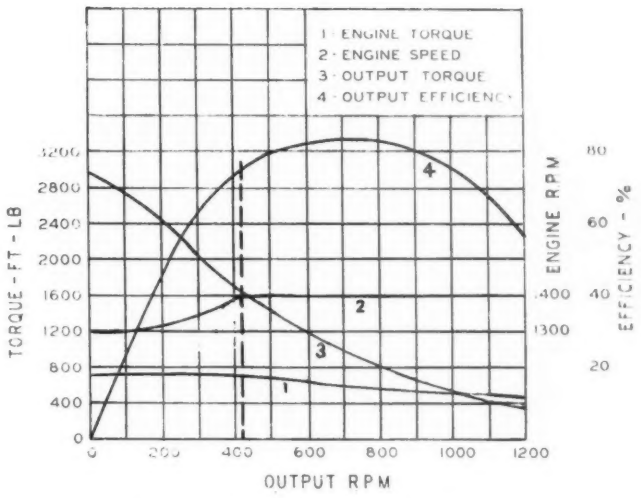


FIG. 8. Torque converter curves.

come in the higher speeds. For this reason, many "high" speed clutches give far more trouble and have higher maintenance costs than low speed clutches.

B. Electrical. In this discussion, no account will be taken of a-c power for drilling rigs because of the relatively poor characteristics of a-c for hoisting and the fact that central station power is seldom available for drilling services. Generation of alternating current on the site in a rig power plant is impractical and undesirable unless under highly specialized circumstances. The discussion, therefore, concerns only d-c power applications of the basic Ward Leonard type. This type of power has proved ideal throughout industry for all types of hoisting and transportation involving heavy accelerations, high peak loads of short duration, and variable speed loads.

Fig. 5 shows a speed torque curve of the 1000 hp exemplary hoist load, using d-c motors. As can be noticed, the main speed steps are identical with the mechanical hoist example in Fig. 4, but the low and high gears are omitted and unnecessary. This, therefore, calls for only four speeds instead of six to give the total load-speed range required.

It can be seen that the power produced by the motor drive is almost identical with a true mean horsepower curve. This is due to the fact that, being electrically coupled to the load, the engines can run at full speed and produce full horsepower for each step of the load, as long as the driving motors can withstand the torque (or current) demand of the load.

Fig. 6 gives a composite set of engine to motor shaft curves, which are interesting when compared directly with those in Fig. 8.

The chief advantages of electric motor drive over direct mechanical drive are:

(a) Starting torques up to 225 per cent (115 per cent for mechanical).

(b) Electrical load coupling involves no slipping clutches or wearing out of mechanical parts — can stall at any load up to full load, indefinitely.

(c) Engines can deliver full horsepower to motors at any speed at which latter can absorb it.

It should be remembered that, except for almost instantaneous peak torque available over the accelerating period, the electric motor itself does not incorporate speed ratio changes. It is essentially a high starting torque device, with full torque almost instantly obtainable at any speed up to full speed. By using oversize motors and generators, high current capacities are usable at the same horsepower engine output, thus giving the effect of torque multiplication.

C. Hydraulic. Fig. 7 shows the application of a hydraulic torque converter to our 1000-hp hook load, and an inspection of the speed torque characteristics shows it to be practically ideal. The shaded area in this case shows a slight gain over the theoretical 100 per cent or ideal curve, because the torque converter increases in efficiency slightly over the portion of its speed range used. In this specific case, only three speeds are required in the hoists to give an ideal curve.

Fig. 8 shows a well known set of specific curves of engine to output shaft performance, which requires little explanation.

The torque converter, when used over its efficient range, is the only device that, in itself, produces a speed ratio change, allowing the engine to run at full horsepower at full speed and deliver full horsepower at a reduced speed to the delivery shaft. For this reason, it has the most ideal characteristics of all known methods for variable load hoisting operations.

The load accelerating characteristics are not as good as the d-c electric, but the load coupling is almost identical and about as trouble free—no moving mechanical parts being in the friction circuit.

D. Effect on hoist design. As seen from a study of Figs. 4, 5, and 7, either a six, four, or three-speed hoist is required for efficient usage. Any variations in these requirements would mean waste of expenditure for more than the requirements, or failure to perform adequately for less than the requirements. Even the distance between steps of speed changes is sufficiently different to make one machine unsuitable to cover all three methods efficiently.

The hoist manufacturer must clearly build equipment that will be coupled to any of the three transmissions and, while at the time of writing the large torque converters needed for the hoist shown are not available, they undoubtedly will be in the future.

The hydraulic drive, if placed on the engine shafts of multi-engined rigs, places the torque multiplication ahead of the engine coupling transmissions, which correspondingly requires making them capable of up to five times their normal torque rating. This is clearly expensive and undesirable and, therefore, the torque multiplication device belongs in the hoist for greatest economy.

In effect, and for greatest adaptability

of hoists to the three transmission methods, the compromise appears to call for a basic two-speed hoist using a two-speed auxiliary transmission for electrical or hydraulic drive, or a three-speed for mechanical drive. For somewhat deeper drilling, this might require a two-speed auxiliary for hydraulic drive, three-speed for electric, and four-speed for mechanical. For shallower drilling, a single-speed basic hoist would suffice, with a two-speed hydraulic, three-speed electrical, and four or five-speed mechanical auxiliary transmission being used.

In all the above cases, the basic drilling hoist would provide all the standard drilling hoist devices and the transmission would be properly engineered as a unit to suit the basic transmission systems used.

Some discussion of fully automatic hoists has recently appeared in print, but the author feels that the tasks performed by a drilling hoist and the varying speeds and loads required for all these tasks, are so variable that it would be impractical to make all these automatic. Certain operations can easily be made automatic, either in the hydraulic or electric drives, but the most practical approach appears to be to give the operator good instruments that indicate loads on, and speeds of, key shafts and let him control his own machine as his experience dictates.

E. Rotary drives. The mechanical gear change for rotary drives must be handled cautiously to avoid excessive torque loading of drill pipe and, in any case, should never be operated on the engine governor, for this device would merely open up as load increased and place full engine torque on the input end of the gear train, with unfortunate results to the drill pipe.

The same applies to the torque converter, which can, at any point of engine throttle setting, multiply the set torque by about five, unknown to the operator, unless it is provided with automatic torque limiting devices.

Electrically, the motor can simply be set to any desired stalling torque (or current), and provides the safest method of preventing excessive overload. This drive has infinitely variable speed from zero to full speed.

F. Emergency or standby drives. The torque converter provides the most ideal method of providing for emergency hoisting service in case of breakdown of the main equipment. In such cases, the efficiency of the drive is not nearly as important as a high range of operating torque, for which this device is best adapted. Normally, an emergency hoisting unit needs to be only 10-20 per cent of the main hoisting engine so as to get the operator out of major trouble in case of breakdown of the main unit.

G. Pump drives. The slush pump is essentially designed as a constant torque piece of equipment and torque multiplication is undesirable for pump drives. Any increase of torque beyond design loading cannot be carried by the pump for long periods of time. Increased pressure capacity must be obtained by reducing liner sizes.

Normal mechanical drives to slush pumps are satisfactory and of high efficiency from pump drive pulley to pump. One disadvantage is the inability to stall or slip against full torque as is sometimes, although rarely, required.

On electric drives, any load up to full torque may be stalled against the pump as desired and full torque may be maintained at all times. Up to 225 per cent full load torque is available for short periods, when required.

On hydraulically driven rigs, the pumps are most efficiently driven direct from engine drives and, as previously stated, the torque converter best belongs on the hoist, where its characteristics are suitably employed. The only exception to this is, possibly, on workover rigs where temporary torque multiplications are very useful on occasions. In such cases, however, automatic limitation of torque multiplication is advisable.

Hydraulic couplings between engines and pumps permit of full torque and 100 per cent slip of load when desired, similar to electric drives. As slipping of pumps is rarely required, there is some doubt of the economic value of hydraulic coupling pump drives. One pump on a rig, equipped with a slip drive and of low volume, should be sufficient for full slip loads, since no volume passes on a stall.

If sufficient engine capacity is provided for driving pumps to full torque and speed, the writer sees no economic justification for the use of torque multiplication for this service. It is quite certain that limited horsepower purchased cannot be substituted for by torque multiplication. If not carefully engineered and used with discretion, torque multiplication definitely can harm pumps.

● **Portability and rigging up.** In selecting drilling equipment of the ultra heavy type, considerable thought must be given by the operator to the cost and complexities of foundations, erecting, and tearing down of the rig in service.

The straight mechanical rig of large size requires a solid foundation, preferably of concrete, and large, expensive, substructures to keep the engines and transmissions in proper alignment. Failure on this score will cause high chain, bearing, and shaft maintenance costs. The larger and more rigid these units become, the greater is the necessity of rigid foundations for reducing maintenance costs.

The hydraulic rig, which uses the same in-line rigging up system as the mechanical, is subject to the same limitations as above. Electrically, the hoist and drive motors are close coupled on small foundations and the main driving engines and pumps can be situated wherever desired by the operator, since they are connected to other rig parts by cables. The electric rig equals, or even betters, steam rigs in the ability to fit a rig layout to the surroundings.

Tonnages on moving are not as important as the number of packages and simplicity of assembly, or as the maximum flexibility of installation arrangement. All these features have definite economic value and become more important as the equipment becomes of higher capacity. All these factors must be considered by the operator to fit his own circumstances. The writer would say that the first requirement is that the equipment shall have adequate ability to do the job in hand. The second requirement is low overall operation cost. First cost is of secondary consideration because, on deep drilling operations, very large ton mileages are carried through the hoist and other rig members, all of which carry their definite "cost per ——" operating penalty.

● **Summary.** Summarizing the data given, it can be seen that, from an efficient performance viewpoint for heavy duty large scale tonnage movement, either the electrically or hydraulically operated hoist is far more desirable than the mechanical.

Field performance indicates that the lower efficiency of the hydraulic drive is largely returned in improved hoist performance, but that the electrical drive is more efficient and, with modern improvement, such as the electro-hydraulic governor, should give somewhat lower engine operating costs and simpler remote control apparatus.

It would seem, however, that "the race goes to the swift." Hydraulic converters are not yet available in the sizes necessary and the electrical industry is certainly not in pace with the oil industry in its ability to supply "standard assemblies" of electrical equipment out of stock, or on rapid delivery, even in normal times. Most operators would expect to await delivery of special "extras" on rigs or for specially designed rigs, but "on the shelf" designs of either type must be available.

As in the transportation industry, the railroads for example, the first flexible drive was hydraulic. It is now all electric. On automobile equipment, hydraulic drive is now taking hold. Will electric be next?

The author believes that, with proper application and boiling down to essentials, the electrical method has the inherent edge in reduction of moving parts, simplicity, and flexibility for oil-field usage. This is true only by a small margin and only if hoisting equipment is properly designed for electrical usage. The answer appears to be a matter of logistics—supply, service, and cost—and there is a place in the sun for both methods in the full range of drilling equipment.

Finally, a heavy rig, involving from $350,000 up, should not be an overnight purchase, but should be thoroughly engineered from a long life, low maintenance cost standpoint.

The author wishes to thank Shell Oil Company, Inc., for providing the operational data used in preparation of this paper and, also, the *Oil and Gas Journal*, the General Electric Company, and Twin Disc Clutch Company, for assisting with the illustrations. ★★★

Hydrocarbon absorption and fractionation process design methods

Part 8. Comparison of Absorption Calculation Methods.

By WAYNE C. EDMISTER*,
Hydrocarbon Research, Inc.

EXCLUSIVE

In the previous chapter (Part 7) the calculation procedures used in solving different types of absorption and stripping design problems by the Sherwood graphical method were presented and illustrated. The graphical method was presented first and separately for clarity and to avoid confusion. There is only one graphical method, whereas there are several related analytical methods, all stemming from the same fundamental equations. Therefore, the calculation procedures outlined and illustrated below will cover three different methods of applying the fundamental equations.

These methods are: (a) The *series* application of fundamental equation, using absorption (or stripping) factors for each plate; (b) the *effective* absorption (or stripping) factors short-cut of Horton-Franklin wherein the effective factors are estimated at different points in the column for each component, and (c) the *effective* absorption (or stripping) factor method of Edmister, where the effective factors are functions of the values of the factors at the top and bottom plates.

The step-by-step procedures for these methods will be presented with calculation illustrations for the same problem, for which the recoveries for all components in a given system (i.e., oil-gas ratio, number of theoretical stages) are the objectives of the problem. All other problems may be made a special case of this one. In addition, a solution of the same problem by the Sherwood method is included for comparison.

SERIES APPLICATION OF EQUATIONS

The series method of applying the fundamental equations (43) and (45), which are developed in Part 5, involves the use of separate absorption factors on each plate for each component throughout the absorber, and substitution of these factors in the general equations. As the procedure for stripping is similar to that for absorption, the discussion will be limited to absorption. In making absorption calculations by this method the procedure followed is:

Step 1. Make a rough estimate of amounts of each component absorbed and then calculate the rich oil temperature by a heat balance.

Step 2. After an estimate is made of the total mols of gas absorbed and the corresponding rich oil temperature is calculated, it is necessary to estimate the distribution of knockout and temperature on each plate of the tower. Although no rule can be devised to give these distributions exactly, the following simple rules have proved satisfactory for this purpose in all cases tried:

$$\left(\frac{V_1}{V_{n+1}}\right)^{1/n} = \frac{V_i}{V_{i+1}}$$

and

$$\frac{V_{n+1} - V_{i+1}}{V_{n+1} - V_1} = \frac{T_n - T_i}{T_n - T_o}$$

These equations, which were given in Part 5 as equations (49) and (50), assume constant per cent absorption on each plate throughout the tower and temperature change proportional to the contraction. The predicted material balances and temperatures on each plate may differ considerably from those actually obtained in a given absorber, but use of these predictions gives an overall absorption efficiency for each component that agrees closely with plate-to-plate calculations.

Step 3. Use of the above empirical rules will enable the calculation of vapor and overflow rates and oil temperatures on each plate, and hence the ratio L/V on each plate can be computed. The values of K(=y/x) can be obtained for each component on each plate, and A(=L/VK), the absorption factor for each component, is computed throughout the tower.

Step 4. Substitution of these values for each component in equation (43) gives the absorption efficiencies from which the residue gas composition and the total mols absorbed can be calculated.

The following example was used by Horton-Franklin and is included here so that comparisons of various methods might be readily made. Horton and Franklin used vapor and total pressures in estimating phase equilibrium constants. In this and subsequent examples employing this problem, vapor and total pressures will be used for consistency in making comparisons. For these conditions fugacity equilibrium constants would be used in normal design practice.

Example 18. The fundamental equation method will be applied to an absorber of four theoretical plates operating at a pressure of four atmospheres and using 1.103 mols of 90 F lean oil per mol of wet gas to find the absorption recoveries of each component from the wet gas. Following are the compositions and relative quantities of the wet gas and the lean oil:

Component	Mols wet gas	Mols lean oil
Methane	0.286	..
Ethane	0.157	..
Propane	0.240	..
n-Butane	0.169	0.022
n-Pentane	0.148	0.055
Lean oil	..	1.026
Total	1.000	1.103

In order to estimate the values of L, V, and T at each plate, the following approximations are made:

(a) The mols of condensible knockout per mol wet gas = 0.449, which value is usually obtained by an approximation calculation using a simpler method;

(b) The distribution of the contraction from plate to plate is found by equation (49) (Part 5), which gives:

$$\left(\frac{V_1}{V_{n+1}}\right)^{1/n} = \left(\frac{0.551}{1.000}\right)^{1/4} = 0.861 = \frac{V_1}{V_{i+1}}$$

(c) Knowing V_{i+1} at any point, L_i can be calculated by the material balance from the lean oil and the off gas:

$$L_i = L_o + V_{i+1} - V_1$$

(d) By a heat balance the rich oil temperature is found to be 115 F, and, assuming that the temperatue change is proportional to the contraction, the temperature at any plate "i" is found as follows:

$$115 - T_i = (115 - 90)\,\frac{1.0 - V_{i+1}}{1.0 - 0.551}$$

$$= 25\,\frac{1.0 - V_{i+1}}{0.449}$$

From the results of the above four approximations, material balances are made on each plate to get the mols of oil and gas. The L and V quantities and the temperatures are listed in Table 24.

For the purpose of illustrating the method, the equilibrium constants used in calculating the absorption factors

TABLE 24—Values of L, V, and T for Example 18.

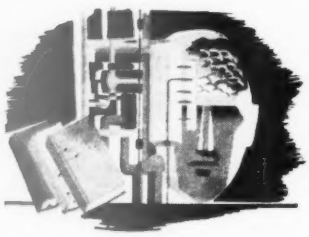
	Lean oil	Plate 1	Plate 2	Plate 3	Plate 4	Wet gas
Mols oil	1.103	1.192	1.294	1.413	1.552	..
Mols vapor	..	0.551	0.640	0.742	0.861	1.000
Temp. oil, F	90	95	101	107	115	..
L/V	..	2.16	2.02	1.90	1.80	..

*Home address, 7 Gilmore Court, Scarsdale, New York.

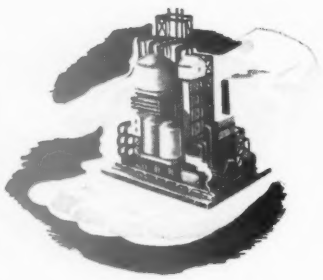
1947
was a paradox!

Although 1947 was one of the most successful years we've ever had, it also brought us one of our biggest disappointments.

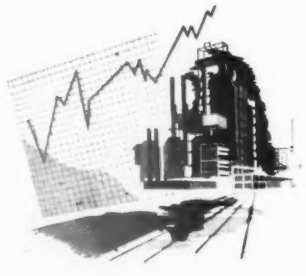
That may seem like an odd statement to make — particularly when we recall that during the year we were able to add to the record accomplishments like these . . .



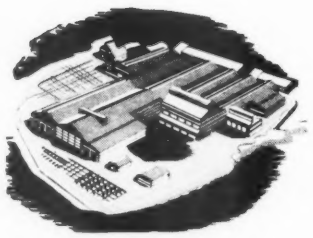
Engineering completed on a large number of major refining projects . . . up-to-the-minute on every project in the house.



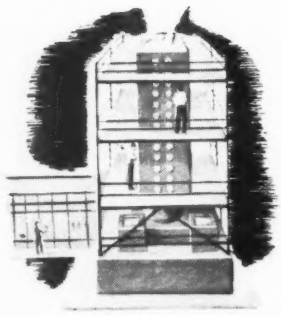
A variety of new units completed and placed on stream, including the first Kellogg small-capacity *Fluid* Catalytic-Cracking unit . . . construction started on a number of major projects.



"On-stream efficiency" beyond all expectations, established by Kellogg-built *Fluid* "Cats".

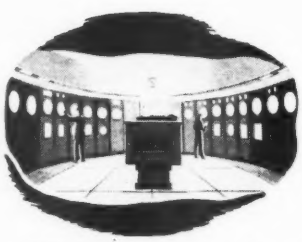


A totally new method perfected for bending pipe as large as 100 inches in diameter.



A brand new process completed for making high-temperature steel alloys, with physical properties and performance characteristics that eclipse all previous standards.

The first Solexol Plant for the refining of fats and tallows placed on stream, at Baltimore...a vitamin plant also completed.



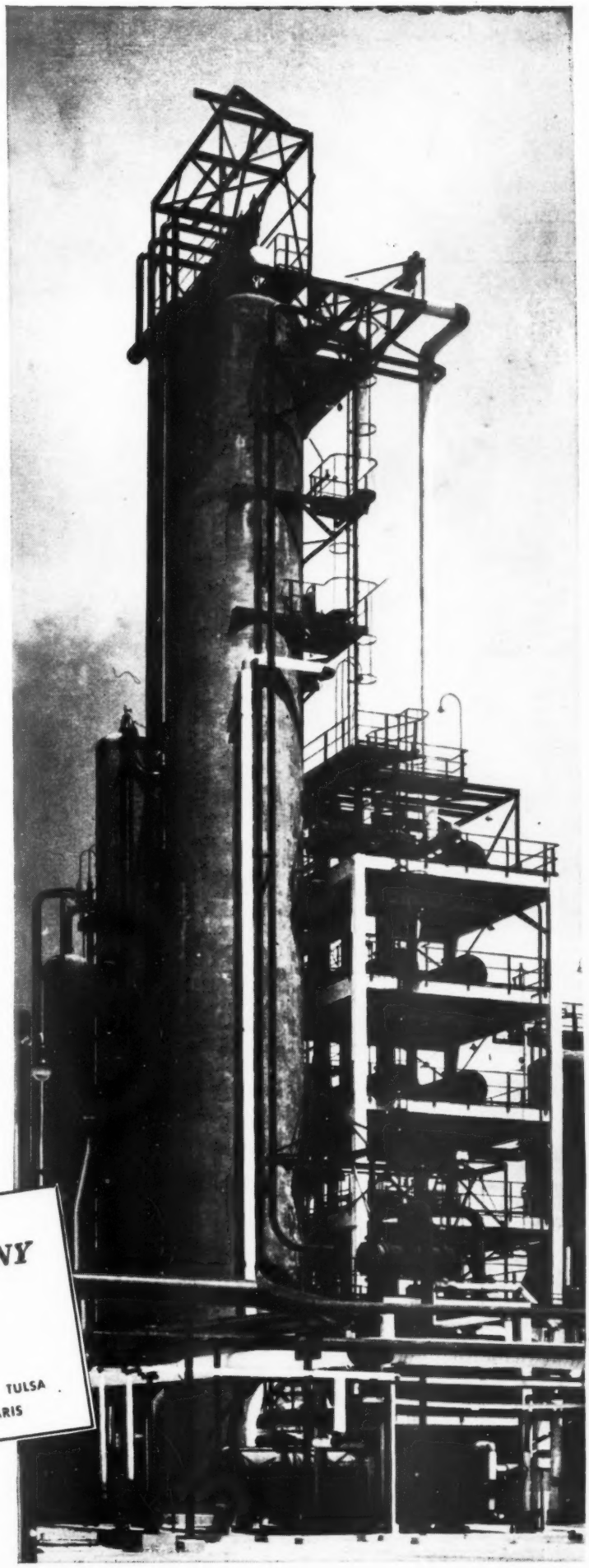
Engineering worked out for the first *Combination* plant embracing *Fluid* Catalytic-Cracking.

With all this, we're still not very happy, because the one thing we wanted to do most was to get back to pre-war construction time schedules — putting process equipment on stream promptly — and that *one* all-important aim was limited by critical shortages of steel and other materials.

The fact that many other industries were adversely affected by the shortage of materials is small consolation. Actually, suppliers have given us and our customers a fair share of what was available, and perhaps a little more.

Nor do we get much satisfaction out of remembering that even though our construction crews were ready, we had to refrain—in the interests of economy—from putting them into the field except on those jobs where delivery of all critical items was assured, so that once work was started it could continue without interruption.

With the international situation being what it is, there is no telling when the shortage of materials will be over. But this much we do know—that by giving *every new order immediate engineering service*—by keeping our purchasing and expediting people scouring the country for materials 24 hours a day—by using ingenuity in the matter of specifications—we'll accomplish much more than appears possible under existing conditions.



THE M. W. KELLOGG COMPANY
A SUBSIDIARY OF PULLMAN, INC.
ENGINEERS TO THE PETROLEUM INDUSTRY

NEW YORK · HOUSTON · JERSEY CITY · TORONTO · LOS ANGELES · LONDON · TULSA · PARIS

TABLE 25—Values of $K = \frac{\pi}{P}$ at each plate for Example 18.

	Plate 1	Plate 2	Plate 3	Plate 4
Methane	50.0	51.5	53.6	55.0
Ethane	12.7	13.4	14.1	15.0
Propane	3.0	3.26	3.50	3.80
n-Butane	0.824	0.902	0.974	1.09
n-Pentane	0.25	0.275	0.300	0.35

TABLE 26.—Value of $A = \frac{L}{KV}$ at each plate for Example 18.

	Plate 1	Plate 2	Plate 3	Plate 4
Methane	0.0432	0.0392	0.0354	0.0327
Ethane	0.170	0.151	0.135	0.120
Propane	0.720	0.620	0.542	0.473
n-Butane	2.62	2.24	1.95	1.65
n-Pentane	8.64	7.34	6.33	5.14

TABLE 28.—Series equation results for Example 18.

	Absorbed components, Mols/hr	Residue gas, Mols/hr	mol fraction
C_1	0.0094	0.2766	0.4985
C_2	0.0192	0.1378	0.2480
C_3	0.1203	0.1197	0.2160
nC_4	0.1547	0.0143	0.0258
nC_5	0.1415	0.0065	0.0117
Total	0.4451	0.5549	1.0000

TABLE 29.—Location of effective absorption factor for Example 19.

Component	Range of A values (see Example 18)	Ratio i/n (see Table 14 in Part 5)	Effective A location, Plate "i"
Methane	0.032 to 0.043	1.0	4.0
Ethane	0.12 to 0.17	0.9	3.6
Propane	0.47 to 0.72	0.8	3.2
n-Butane	1.65 to 2.62	0.7	2.8
n-Pentane	5.14 to 8.64	0.6	2.4

were taken as π/P (vapor pressure/total pressure), values of π being read from a vapor pressure chart and P being 4 atmospheres. The same pressures used by Horton-Franklin are used for consistency. The equilibrium constants are tabulated in Table 25 at total pressure of 4 atmospheres for each component at each plate.

The absorption factors for each component on each plate are next found as shown in Table 26:

Using these values of A and the wet gas and lean oil compositions given in Table 26 the absorption efficiencies are computed for each component as shown in Table 27 by means of the fundamental equation (43).

With these absorption efficiencies, the recovery and the residue gas quantities are computed and results given in Table 28.

The total knockout of 0.4451 mols is in sufficiently close agreement with the assumed value that additional calculations are not necessary.

HORTON-FRANKLIN SHORT-CUT

This effective factor method was described in Part 5. The salient feature of this method is the procedure for estimating the effective absorption (or stripping) factors at an effective location depending upon the value of the factor. The step-by-step procedure for this method is as follows when the oil and gas quantities and compositions and the number of theoretical stages are either known or assumed.

Step 1. Approximate the total amount absorbed and then calculate the rich oil temperature by a heat balance.

Step 2. From average L/V ratio and temperature find approximate A (or S) factors to use in locating the *effective* factor. From the tabulated relationship developed by Horton and Franklin (see Part 5), locate the effective factors for each component.

Step 3. Evaluate the effective A (or S) factor for each component. This is done by estimating intermediate vapor and liquid flow rates and temperatures by means of equations (49) and (50) (or a similar relationship) and then finding L/VK (or KV/L) for each component by means of equation (47) (or 48).

The following example which was used by Horton-Franklin, illustrates the above procedure.

Example 19. Solve by the Horton-Franklin effective factor method the same problem used in Example 18 to illustrate the series application of the fundamental equations. The solution will be given step-by-step.

Step 1. From Example 18 we know that 0.445 mols of the wet gas are absorbed and that the temperature varies from 95 F at the top plate to 115 F at the bottom plate. These data will be used in locating effective absorption factor.

Step 2. The locations of the effective absorption factors for this 4 theoretical plate absorber are found as shown in Table 29.

Having the results of Example 18 makes this step a little easier than it would be without the values of A. This does not make much difference, however, because approximate values of A are very readily estimated closely enough for this step.

Step 3. Knowing the location, the effective absorption factor for each component, may be estimated. In computing the L and V quantities at the various effective points for this example, Horton and Franklin used a different and more convenient expression than equation (49) for estimating the V values. This expression is:

$$V_i = V_1^{\frac{n+1-i}{n}} \quad . \quad . \quad . \quad . \quad . \quad (80)$$

With the expression for V given by equation (80), it is a simple matter to solve for T_i from equation (50). For this example with an assumed total absorption of 0.445 mols the expressions for V_i, L_i, and T_i become:

$$V_i = (1.0 - 0.445)^{\frac{4+1-i}{4}} = (0.555)^{\frac{5-i}{4}}$$

$$V_{i+1} = (0.555)^{\frac{4-i}{4}}$$

$$L_i = V_{i+1} + L_o - V_1 = (0.555)^{\frac{4-i}{4}} + 1.103 - 0.555$$

$$L_i = 0.555^{\left(\frac{4-i}{4}\right)} + 0.548$$

$$T_i = T_n - (T_n - T_o)\frac{(V_{n+1} - V_{i+1})}{(V_{n+1} - V_1)}$$

$$T_i = 115 - 25\left(\frac{1.0 - 0.555^{\left(\frac{4-i}{4}\right)}}{0.445}\right)$$

Compute L/V, and T and A values at effective points (see Table 30).

These effective A values are in good agreement with Horton-Franklin's own calculations.

TABLE 27.—Absorption calculations for Example 18.

	C_1	C_2	C_3	nC_4	nC_5
A_1	0.03270	0.1200	0.473	1.65	5.14
A_3A_4	0.00116	0.0162	0.256	3.22	32.50
$A_2A_3A_4$	0.00005	0.0024	0.159	7.21	238.5
Σ_1	0.03391	0.1386	0.888	12.08	276.14
$A_1A_2A_3A_4$	0.00000	0.0004	0.113	18.90	2060.00
Σ_2	0.03391	0.1390	0.001	30.98	2336.14
Σ_1+1	1.03391	1.1386	1.888	13.08	277.14
Σ_2+1	1.03391	1.1390	2.001	31.98	2337.14
$\left(\frac{\Sigma_2}{\Sigma_2+1}\right)$	0.0328	0.122	0.501	0.969	0.9999
$\left(\frac{\Sigma_1+1}{\Sigma_2+1}\right)$	1.00	0.999	0.942	0.408	0.119
L_oX_o	0	0	0	0.022	0.055
$V_{n+1}\ Y_{n+1}$	0.286	0.157	0.240	0.169	0.148
$\left(\frac{L_oX_o}{V_{n+1}\ Y_{n+1}}\right)$	0	0	0	0.130	0.372
$\left(\frac{Y_{n+1} - Y_1}{Y_{n+1}}\right)^*$	0.0328	0.122	0.501	0.916	0.956

*Using equation (43) (Part 5)

TABLE 30.—Computation of effective A values for Example 19.

Component	"i"	V_i	L_i	T_i	L/V	$K=\frac{\pi}{P}$	Effective A
Methane	4.0	0.863	1.548	115	1.79	55	0.0327
Ethane	3.6	0.814	1.491	112	1.83	14.5	0.1260
Propane	3.2	0.767	1.437	109	1.87	3.60	0.519
n-Butane	2.8	0.724	1.386	106	1.91	0.95	2.01
n-Pentane	2.4	0.682	1.338	103	1.96	0.275	7.13

PRECISION SCIENTIFIC

PRECISION

"Precision Engineered"

IS NOT AN IDLE PHRASE

For behind it lies more than thirty years of experience and countless thousands of engineering man hours . . . a steady addition of bits of knowledge . . . of manufacturing experience . . . of watching performance on the job . . . of encouraging young minds with new ideas. Painstaking craftsmanship, plus unending attention to detail has developed laboratory and production control equipment unequalled for accuracy and dependability. In laboratories throughout the world the name "Precision" means quality—in performance, in appearance, in operation and absolute accuracy—in fact, in every detail that will help the laboratory do the job better, faster and easier. Truly, "Precision Engineered" is **NOT** an idle phrase.

See your Laboratory Supply Dealer

He knows the value of "Precision Equipment" and he is trained to help solve your equipment problems. Rely on him for advice and counsel, backed by "Precision Engineering."

Precision's New Home . . At Chicago, Illinois

Precision Scientific Company

3737 WEST CORTLAND STREET — CHICAGO 47 ILLINOIS, U.S.A.

★ ★ ★ *Scientific Research and Production Control Equipment* ★ ★ ★

Step 4. The absorption recovery efficiencies will next be computed for four theoretical plates by means of equation (47) with or without the use of Fig. 28. Values of Y_o must first be found for n-C_4 and n-C_5 (the two components appearing in the lean oil). Using equation (34) in Part 5, and assuming that $V_o = V_1$, gives:

$$Y_o = K_o X_o \frac{V}{V_{n+1}} = 0.555\ K_o X_o,$$

which is used to make following calculations:

	$K = \frac{\pi}{P}$ @ 90°F*	X_o	Y_o
n-C_4	0.77	0.022	0.0094
n-C_5	0.22	0.055	0.0067

The values of Y_o will be used in the calculations given in Table 31.

The overall recovery efficiencies for the n-C_4 and n-C_5 are not obtained as such, in this method. In order to make comparisons, the recovery efficiencies found by this method are calculated and tabulated below.

Component	E_a, absorption recovery efficiency
Methane	0.0325
Ethane	0.126
Propane	0.500
n-Butane	0.914
n-Pentane	0.956

This is in good agreement with the results of Example 18.

EDMISTER EFFECTIVE FACTOR METHOD

The equations and charts for this effective absorption (or stripping) factor method were developed and presented in Part 5. The principal feature of this method is the technique for evaluating the effective absorption (or stripping) factors, which are formulated as functions of the terminal (top and bottom) conditions, independent of the number of plates.

Process design calculations by this method are made in the following steps for an absorption problem where the relative oil and gas quantities and the number of theoretical plates are given and the component recoveries are desired. In outlining the calculation procedure of this method, the steps included for estimating top and bottom plate temperatures and L/V ratios are the same as those used in the previous examples. It will be recalled that this intermediate L, V, and T procedure was proposed by Horton-Franklin. These internal temperature and L/V computation steps, however, are not part of the proposed method, which could be used as readily with any procedure for estimating terminal plate conditions. For consistency and also for want of a better method, the method used previously for estimating internal L and V quantities and temperatures will be included in this procedure for estimating terminal (top and bottom) plate conditions. The procedure will be described for absorption. For stripping the procedure is analogous.

*Lean oil temperature, which is used for this calculation.

Step 1. Approximate or assume the quantities of each component absorbed in order to prepare the way for more precise calculations. Make a component material balance and obtain the off gas and the rich oil.

Step 2. With the gas and oil quantities thus obtained by this material balance (Step 1) and the given temperatures of the entering lean oil and wet gas streams, make a heat balance to find the rich oil temperature. In making this heat balance it is necessary to assume the residue gas temperature, which will be checked later in Step 4.

Step 3. Estimate the quantities of liquid leaving the top plate and of vapor leaving the bottom plate of the absorber. This is done by using equation (49), which assumes a constant percentage absorption on each theoretical plate, and material balances.

Step 4. Estimate the temperature on the top and bottom plates by using equation (50) and substituting the rich oil temperature from Step 2 and the vapor quantities from Step 3.

Step 5. Compute values of A_1 and A_n, the (L/KV) absorption factor for each and every component in the wet gas at the top and bottom plate conditions.

Step 6. Where the lean oil contains appreciable quantities of light components so that stripping might be the prevailing transfer mechanism the stripping (KV/L_o) factors must be computed at the terminal plates.

Step 7. Find effective absorption (and stripping) factors from the terminal values of the factors, using Figs. 29 and 30.

Step 8. Substitute in equations (51) and (54) and solve for the absorption efficiency, using Fig. 28 in evaluating one of the functions. In making this computation it becomes apparent which mechanism, absorption or stripping, prevails for the doubtful components.

Step 9. Make component material balance to compute the exhaust gas and rich oil compositions and quantities.

The solution of the following problem, which is the same one solved in Examples 18 and 19, illustrates the above procedure.

Example 20. The absorption efficiencies for each component of the problem used in Examples 18 and 19 will be checked by the Edmister Method. The results of the preliminary calculations made for Example 19 will be used in this solution so as to avoid repeating these steps of the computations.

The first six steps are not necessary for this example, because we can use the results of Examples 18 and 19. Starting with the values of A_1 and A_n from Example 18, the effective absorption factors may be computed.

Step 7. Using equations (59) and (62), which state:

$$A_e = \sqrt{A_n(A_1+1)+0.25} - 0.5$$

$$A' = \frac{A_n(A_1+1)}{A_n+1}$$

the effective absorption factors are found in Table 32 for each component in the wet gas:

Figs. 29 and 30 may be used instead of the equations in finding values of A_e or A'. It is of interest to compare A_e and A' for the same components. These differences are significant where the A' term is important, namely, n-C_4 and n-C_5.

Step 8. Substitute in equation (51) and find the net absorption of each component. In making these computations, Fig 28 is used to obtain the values of the functions of A_e. The balance of the calculations are made with a slide rule. The following tabulation gives these computations. Values of A_e are required for all components but A' is only used for components that appear in both wet gas and lean oil. These calculations are shown in Table 33.

TABLE 31.—Absorption computation for Example 19.

Component	Effective A	$\frac{Y_{n+1}-Y_1}{Y_{n+1}-Y_o}$	$Y_{n+1}-Y_o$	$Y_{n+1}-Y_1$ Mols absorbed	Residue gas Y_1
Methane	0.0327	0.0327	0.286	0.0088	0.2772
Ethane	0.1260	0.126	0.157	0.0198	0.1372
Propane	0.519	0.500	0.240	0.1200	0.1200
n-Butane	2.01	0.970	0.1596	0.1545	0.0145
n-Pentane	7.13	1.00	0.1413	0.1413	0.0067
				0.4444	0.5556

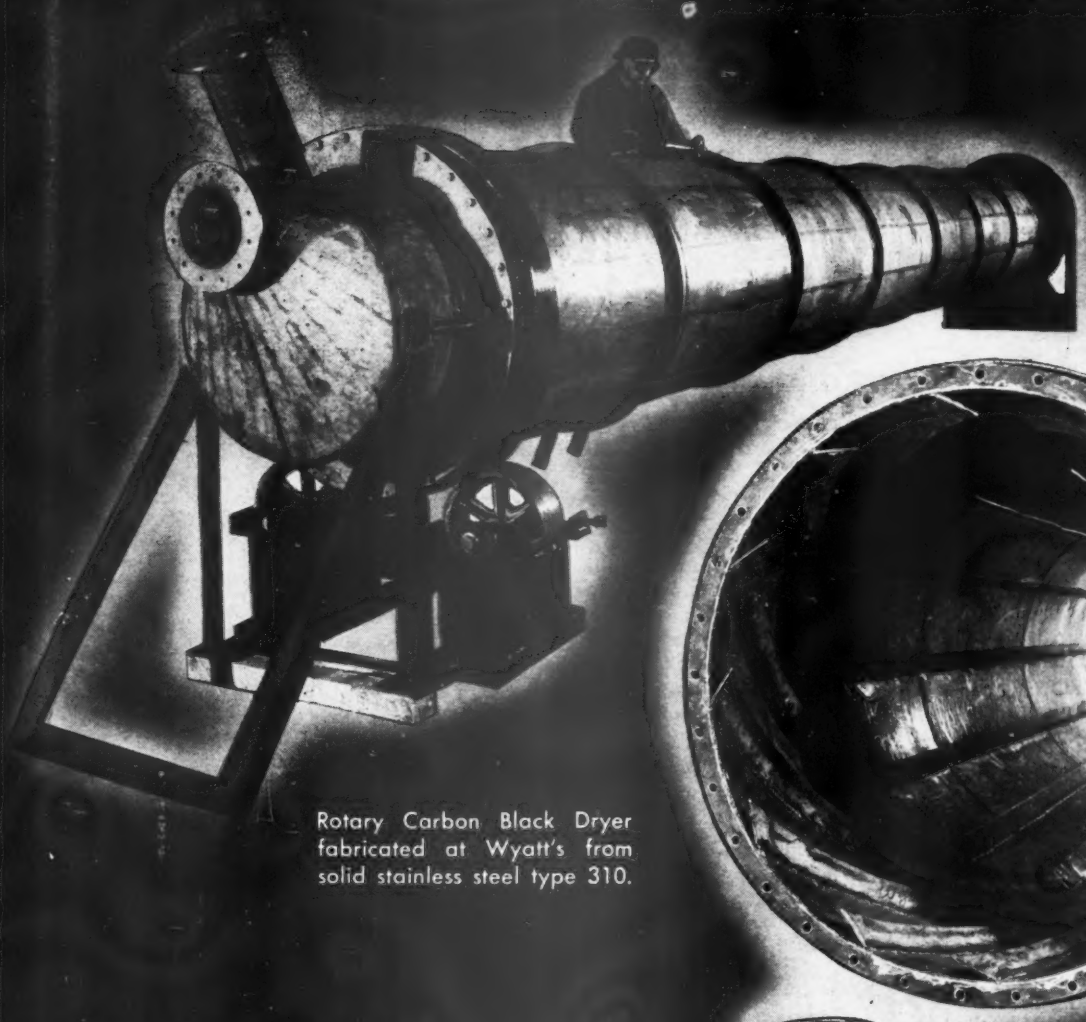
TABLE 32.—Effective absorption factors for Example 20.

Component	A_1	A_n	$A_n(A_1+1)$	$\sqrt{A_n(A_1+1)+0.25}$	A_e	A'
Methane	0.0432	0.0327	0.0341	0.5330	0.0330	0.0330
Ethane	0.1700	0.1200	0.1404	0.6243	0.1243	0.1254
Propane	0.720	0.473	0.813	1.030	0.530	0.5520
n-Butane	2.62	1.65	5.98	2.498	1.998	2.257
n-Pentane	8.64	5.14	49.55	7.06	6.56	8.075

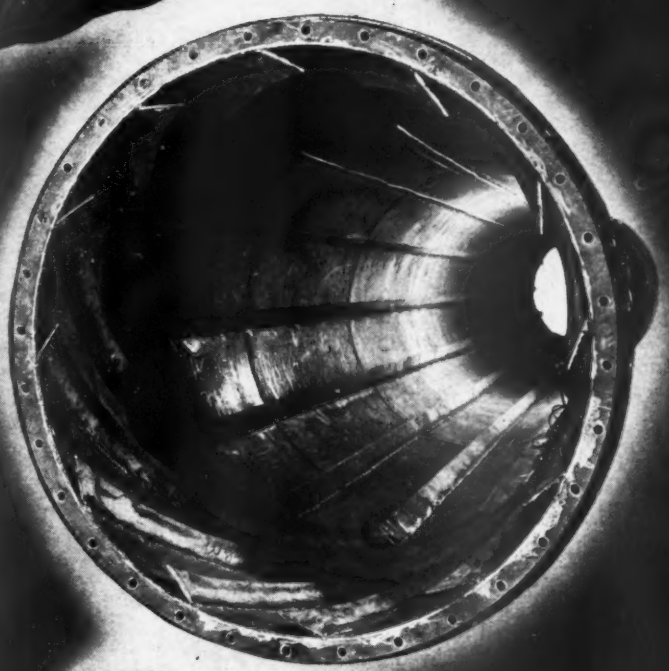
TABLE 33.—Absorption efficiencies for Example 20.

Component	Wet gas V_{n+1} Y_{n+1} mols	Lean oil L_oX_o mols	A_e	A'	$\left[\frac{A_e^{n+1}-A_e}{A_e^{n+1}-1}\right]$	$\left[1-\frac{LoXo}{A'V_{n+1}Y_{n+1}}\right]$	E_a
Methane	0.286		0.0330		0.0330	1.00	0.0330
Ethane	0.157		0.1243		0.124	1.00	0.124
Propane	0.240		0.530		0.508	1.00	0.508
n-Butane	0.169	0.022	1.998	2.257	0.97	0.942	0.915
n-Pentane	0.148	0.055	6.56	8.075	1.00	0.954	0.954

SUPERIOR FABRICATION FOR THE CARBON BLACK INDUSTRY



Rotary Carbon Black Dryer fabricated at Wyatt's from solid stainless steel type 310.



Equipment such as this manufactured for the Carbon Black Industry is typical of Wyatt's superior fabricating service designed to meet the exacting requirements of modern industry.

WYATT METAL & BOILER WORKS

Wyatt's

HOUSTON - DALLAS

In this particular problem the lean oil contains two of the components that appear in the wet gas; namely, n-butane and n-pentane. The above computation of $(1-L_oX_o/A'V_{n+1}Y_{n+1})$ proves that the net transfer of these components will be from the gas to the oil. Had the value of this correction function been negative stripping would have prevailed and it would have been necessary to apply the stripping equation to these components.

As for the balance of the lean oil, there will be a small amount of stripping, which could be computed if the lean oil were broken down into components and if vapor-liquid distribution constants are available for these components. This is done by means of the stripping equations simultaneously with the absorption computations.

Step 9. From these absorpton efficiencies the following component material balance is made. In making this calculation, the absorption efficiency is applied to the wet gas throughout, including the n-C_4 and n-C_5. The amounts of these components in the lean oil are added to the quantities absorbed to get the total in the rich oil. See Table 34.

The results are in good agreement obtained by the other methods in Examples 18 and 19.

The last two calculation procedures and examples use effective absorption factors, determined in different ways. It is of interest to note the differences in the Horton-Franklin effective absorption factor and the two Edmister effective absorption factors (see Tables 30 and 32).

SOLUTION BY SHERWOOD METHOD

For purposes of comparisons, the same problem used in Examples 18, 19, and 20 will be solved by the Sherwood method. The procedures for this method were presented in the previous chapter.

Example 21. The Sherwood method will be used to solve the same problem solved by the fundamental equation in Example 18 by the Horton-Franklin short-cut method in Example 19 and by the Edmister method in Example 20. This solution will make possible a comparison of the results by each of these methods. This problem falls into the Type I of the three classifications of absorption design calculations discussed in Part 7.

TABLE 34.—Component material balance for Example 20.

Component	Material in, mols — Wet gas	Lean oil	Material out, mols — Residue gas	Rich oil
Methane	0.286		0.2765	0.0095
Ethane	0.157		0.1375	0.0195
Propane	0.240		0.1180	0.1220
n-Butane	0.169	0.022	0.0144	0.1766
n-Pentane	0.148	0.055	0.0068	0.1962
Lean oil		1.026		1.0260
Total	1.000	1.103	0.5532	1.5498

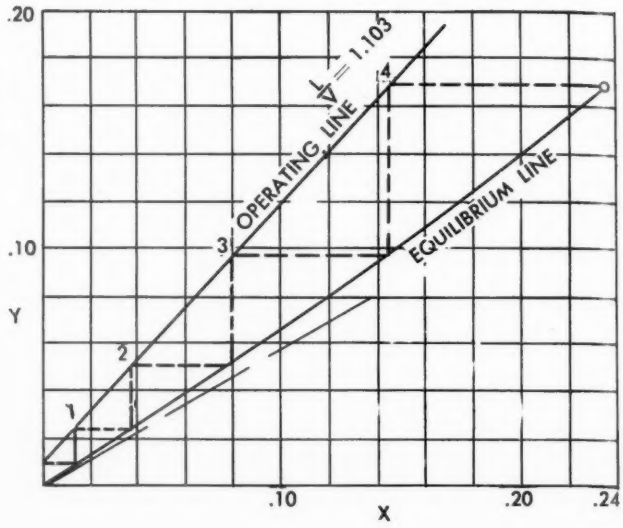


FIG. 37. XY diagram for n-butane in examples comparing Sherwood's method with other methods for Type I absorber calculations.

Solution. Assume an average temperature of 105 F and use vapor pressures.

$V_{n+1}=1.0$, $L_o=1.103$, $L/V=1.103$.

Steps 1, 2, and 3. For the first computations the effect of the presence of n-C_4 and n-C_5 in the lean oil will be neglected. These calculations are given in Table 35.

Steps 4 and 5. The corrected L/V ratio for the next computation is:

$$\frac{L(1+\Sigma X)}{V}=\frac{1.103+0.384}{1.0}=1.487$$

Calculations of the absorption and residue gas are given in Table 36:

Step 6. A graphical treatment of the key component, which is n-butane will now be made. The slope of the equilibrium curve for n-C_4 at the origin is:

$K(\Sigma Y_L)=(0.975)\ (0.5721)=0.558$.

A point on the rich end of the equilibrium curve is located by finding X in equilibrium with $Y_R=0.169$ as follows:

$$X_R=\frac{Y_R}{K}\left(\frac{1+\Sigma X_R}{\Sigma Y_R}\right)=$$

$$\frac{0.169}{0.975}\left(\frac{1+\frac{0.4279}{1.103}}{1.0}\right)=0.24$$

With this lean end slope and rich end point the equilibrium line is drawn on an XY diagram. The operating line is drawn with a slope of 1.103.

From this plot, $Y_L=0.008$ for n-butane. The mols of n-butane absorbed is 1.00 $(0.169-0.008)=0.161$ vs. 0.143 by step 3 and 0.1567 by step 5. This is not a close enough check so adjustments should be made in the calculations. In making these adjustments, correction should also be made for the presence of n-butane and n-pentane in the lean oil (see equation (47)).

Repeat Steps 4 and 5. Assume the total mols absorbed equal 0.157. Adding the solute in lean oil gives

$$0.457+\frac{0.077}{1.103}=0.527$$

$$\frac{L}{V}(1+\Sigma X)=\frac{1.103+0.527}{1.0}=1.63$$

Adjusted absorption calculations and residue gas are given in Table 37:

Repeat Step 6. In the above calculation the mols absorbed were found to be 0.4294 vs. 0.457 assumed. The XY plot for n-butane will be constructed with the slope at origin of:

$K(\Sigma Y_L)=(0.975)\quad(0.5706)=0.556$

$$X_R=\frac{0.169}{0.975}\left(1+\frac{0.4294}{1.103}\right)=0.240$$

With these points the new equilibrium line for n-butane is drawn on an XY diagram given as Fig. 37 (this is the final plot, the preliminary one is not included). The operating line is located for a slope of $L/V=1.103$ and 4 theoretical plates. From Fig. 37, $Y_L=0.010$ for n-butane. The mols of n-butane absorbed

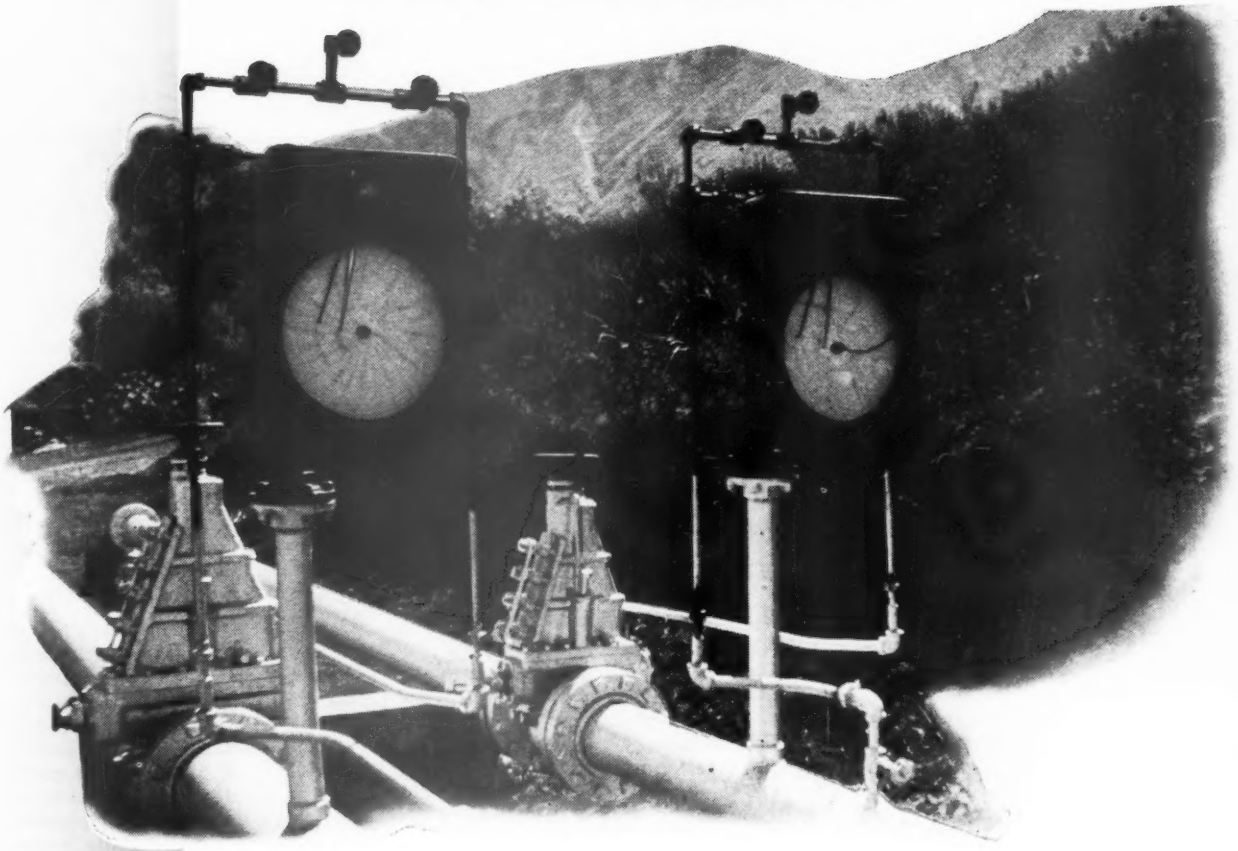
TABLE 35.—Preliminary calculations for Example 21.

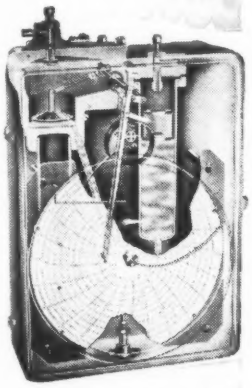
Component	In gas mols/hr Y_R	$K_{105\ F}$ 1 atm. av.	$A=\frac{L}{KV}$	$\frac{Y_R-Y_L}{Y_R}$ Fig. 28	Mols/hr absorbed	Off gas mols/hr Y_L
Methane	0.286	53.7	0.0206	0.0206	0.0059	0.2801
Ethane	0.157	13.9	0.0795	0.0795	0.0125	0.1445
Propane	0.240	3.50	0.315	0.315	0.0756	0.1644
n-Butane	0.169	0.975	1.132	0.845	0.1430	0.0260
n-Pentane	0.148	0.30	3.68	0.99	0.1470	0.0010
	1.000				0.3840	0.6160

TABLE 36—Absorption estimate for Example 21.

Component	$A=\frac{L(1+\Sigma X)}{KV}$	Fraction absorbed Fig. 28	Mols/hr absorbed	Off gas mols/hr Y_L
Methane	0.0276	0.0276	0.0079	0.2781
Ethane	0.107	0.107	0.0168	0.1402
Propane	0.414	0.410	0.0985	0.1415
n-Butane	1.520	0.927	0.1567	0.0123
n-Pentane	4.95	1.000	0.1480	0.0000
			0.4279	0.5721

Where Low-Cost Accuracy Saves Time and Labor





OUT IN THE FIELD, where maintenance is infrequent and tough conditions call for dependable measurement, you'll find that METRIC American Orifice Meters pay off in low-cost accuracy.

When adjustment becomes necessary, simple, functional design makes this quick and easy. Only three tools — screw driver, wrench and pliers are needed.

The fewest possible moving parts go into METRIC American design — only one part between the mercury and the chart record. The float is simply constructed — placed on the low side to make calibration easy. Meters can be cleaned without upsetting adjustment — adjusted without interference with working parts.

METRIC American's low-cost accuracy and easy-to-service design, proved the world over, are the result of years of measurement engineering.

Technical literature, on Indicating, Recording or Integrating Flowmeters, Pressure Regulators, Liquid Level and Flow Controllers will be mailed on request.

AMERICAN METER COMPANY

Albany · Atlanta · Baltimore · Birmingham · Boston
Chicago · Dallas · Denver · Erie · Houston · Joliet
Kansas City · Los Angeles · New York · Orlando
Philadelphia · Pittsburgh · San Francisco · Tulsa

is 1.00 (0.169—0.01) = 0.159 vs. 0.1503 in the above Repeat calculation.

These correspond to 94 and 89 per cent recoveries of n-butane from the wet gas by the graphical and analytical procedures of the Sherwood method and are to be compared with 91.5 per cent by the Edmister method.

The assumed absorption of 0.457 mols for Repeat Step 4 is higher than the value of 0.4294 obtained by Repeat Step 5, yet the results of Repeat Step 6 indicate that ΣX should be about this high. This difference in total recovery is inconsistent with the difference in the results for the key component n-butane by the graphical and analytical calculations. The trouble is in the analytical calculations where the L/KV is computed from the rich L/V and average temperature Ks. Effective L/KV values should be used.

A summary of the Sherwood method results for this example is given in Table 38.

COMPARISON OF RESULTS BY SEVERAL METHODS

The same absorption problem has been solved above by four different methods, three equation methods and one graphical method. Calculation procedures for the equation methods are outlined in this chapter while the procedure for the graphical method is given in Part 7. There are a few distinct differences in the procedures that can only be appreciated by following the example solutions in detail.

One difference is the way in which allowances are made for the presence in the lean oil of the components being absorbed from the wet gas. This is handled the same way in the "Series Equation" and "Edmister Effective Factor" methods. It is handled another way in the "Horton-Franklin" and the "Sherwood" methods. Thus for this problem there are two techniques, each used by two design methods.

Another difference in these methods is the way allowances are made for varying L/V ratio and temperature. This is handled differently in each design method. In the "Series" method absorption factors on each tray are used. In the "Horton-Franklin" and "Edmister" methods, effective absorption factors are used. In the Sherwood method the absorption factors used in the analytical calculations of the fractions of each component absorbed are evaluated from the L/V at the bottom or rich end of the absorber and the K values at an average oil temperature. For strippers, the Sherwood method uses stripping factors evaluated in the same manner.

Horton and Franklin showed that the effective absorption factors were in the rich half of the absorber, the exact location depending upon the magnitude of the factors. From this it appears that the Sherwood analytical procedure is correct for some of the components and approximate for the other components. In some cases the use of an L/V ratio at the rich end and an average K value will, by chance, give the proper effective value of A, but not always.

These effects of these two items are sometimes in the direction of lower absorption efficiency for the Sherwood method. As can be seen by Example 18, the L/V ratio is higher at the top than at the bottom of absorbers. Also, the equilibrium constant, K, is lower at the top than at the bottom of absorbers. Combining these two trends gives substantially higher absorption factors at the top than at the bottom of absorbers. Using the bottom plate absorption factor introduces a larger error for the higher boiling components than the lighter. This is evident from Example 19.

The L/V ratio computed in the repeat steps of Example 21 is about 10 per cent lower than the L/V ratio found for the bottom plate in Example 18 and about 30 per cent lower than the top plate L/V ratio in Example 18. It can be readily appreciated that differences of this magnitude have a direct effect on the accuracy of the results. Likewise, the average K values used in the Sherwood method solution of this problem (Example 21) do not introduce the proper relative volatility constants into the calculations.

The above compares features of these methods for making absorption calculations. Although the qualitative conclusions are correct, the quantitative differences may be questioned because of the assumptions made in prorating the vapor contraction and in estimating the temperatures. It will be recalled that the "knock-out" on each plate was taken as the same percentage of the total and that the temperature change was estimated as proportional to these contractions. This is approximately correct and may not apply in all cases, but it is reasonable to assume that the shrinkage will be essentially thus. Plate-to-plate calculations, made by Horton and Franklin on this same problem confirm this.

In illustrating these absorption process calculation methods, solutions of the same problem were made by each procedure. The problem used is stated in Example 18. For Examples 19, 20, and 21, the same wet gas and lean oil, the same pressure and temperature, and the same K constants were used. In each of these examples the results may be expressed to terms of E_a, the absorption efficiency, which is the fraction recovered from the wet gas and which allows for the effect of the presence of the solute in the solvent. The following tabulation in Table 39 gives a comparison of the results of these computations. Horton and Franklin made plate-to-plate calculations for this same problem and these results are included in this comparison.

As can be seen, the results in Examples 18, 19, and 20 are in good agreement with each other and the plate-to-plate calculations. The results obtained in Example 21 are lower than the others for all components except n-pentane.

In the next installment the absorption-stripping process design method proposed by this author is illustrated by a more comprehensive example showing how to determine whether stripping or absorption prevails for components appearing in both lean oil and wet gas.

★ ★ ★

(Part 9 will be published in an early issue of The Petroleum Engineer.)

TABL7 37.—Repeat calculation of absorption for Example 21.

Component	$A=\frac{L}{KV}$	$\left[\frac{Y_R-Y_L}{Y_R-Y_o}\right]^*$	X_o	$K_o^\dagger$	$Y_o=\frac{V_o}{V_n+1}X_oK_o=0.54X_oK_o$	Y_R	Y_R-Y_o	Mols/hr absorbed Y_R-Y_L	Y_L
Methane	0.030	0.030				0.286	0.286	0.0086	0.2774
Ethane	0.118	0.118				0.157	0.157	0.0185	0.1385
Propane	0.468	0.460				0.240	0.2400	0.1105	0.1295
n-Butane	1.68	0.94	0.022	0.77	0.0092	0.169	0.1598	0.1503	0.0187
n-Pentane	5.45	1.00	0.055	0.22	0.0065	0.148	0.1415	0.1415	0.0065
						1.000		0.4294	0.5706

*From equation (47) and Fig. 28.
†K's at lean oil temperatures, as compared with average value used previously.

TABLE 38.—Material balance for Example 21.

Component	Material in, mols: Wet gas	Material in, mols: Lean oil	Material out, mols: Residue gas	Material out, mols: Rich oil
Methane	0.286		0.2774	0.0086
Ethane	0.157		0.1385	0.0185
Propane	0.240		0.1295	0.1105
n-Butane	0.169	0.022	0.0187	0.1723
n-Pentane	0.148	0.055	0.0065	0.1965
Lean oil		1.026		1.0260
Total	1.000	1.103	0.5706	1.5324

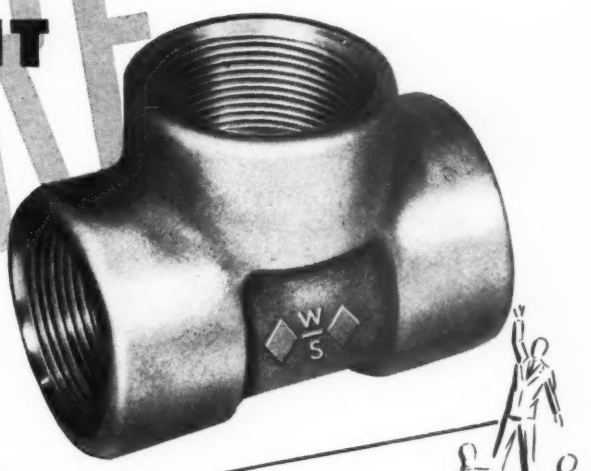
TABLE 39.—Comparison of fractions absorbed from wet gas or absorption efficiencies as found by different methods for same problem.

	Plate-to-plate calculation by Horton-Franklin	Series applications of fundamental equations	Horton-Franklin effective factor short-cut	Edmister effective factor method	Sherwood graphical method
Example		18	19	20	21
Methane	0.0336	0.0328	0.0325	0.0330	0.030
Ethane	0.125	0.122	0.126	0.1240	0.118
Propane	0.506	0.501	0.500	0.508	0.460
n-Butane	0.9185	0.916	0.914	0.915	0.890
n-Pentane	0.9568	0.956	0.956	0.954	0.956

COMPARE

POINT FOR POINT

W-S FORGED STAINLESS STEEL FITTINGS



1. New low prices
2. Many service advantages
3. Available nationally through distributors

Point by point comparison leads to but one conclusion. Watson-Stillman *Forged* Stainless Steel Pipe Fittings have proved to be the best investment for either high or low pressures or temperatures where corrosion is a factor.

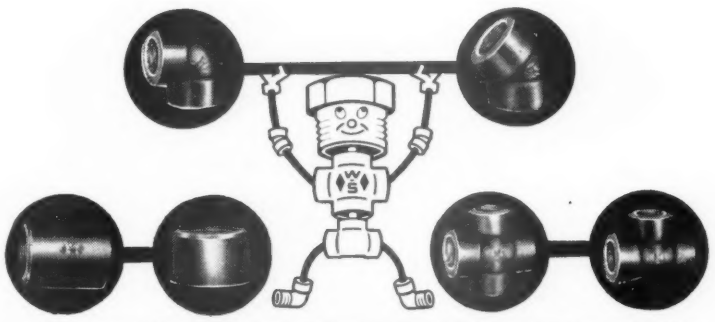
Forging permits a reduction in weight and bulk for a given service because it provides extra strength—extra density—more uniform structure which also adds up to a reduction of maintenance and shut-down losses that can't always be measured fully in dollars and cents.

The Watson-Stillman forged stainless steel line is complete in both screw-end and socket-welding types. Both classifications can be furnished in AISI types 304, 347, and 316, and for use with schedules 40, 80, 160 and double extra-heavy pipe.

Write on your letterhead today for complete information contained in free 44-page Bulletin A-3.

WATSON-STILLMAN CO. • Roselle, New Jersey

Sold Through Leading Industrial Distributors



Designers and Manufacturers of Forged Steel Fittings, Valves, Wire Rope Shears, Hand Pumps, Jacks, Pipe Benders and Hydraulic Equipment

3729A

Automatic control on Portland-Montreal line

By C. D. BATCHELDER* and R. A. ROCKWELL†

ORIGINALLY the Portland-Montreal crude oil pipe line was operated by full manual control; however, about six months ago changeover was made to automatic control. It is the purpose of this article to discuss the reasons for the changeover, the results obtained with the new control system, and tell of the development of the control equipment used in this application. Some background and operating data are given because of their interest and help in giving an objective idea of the control system.

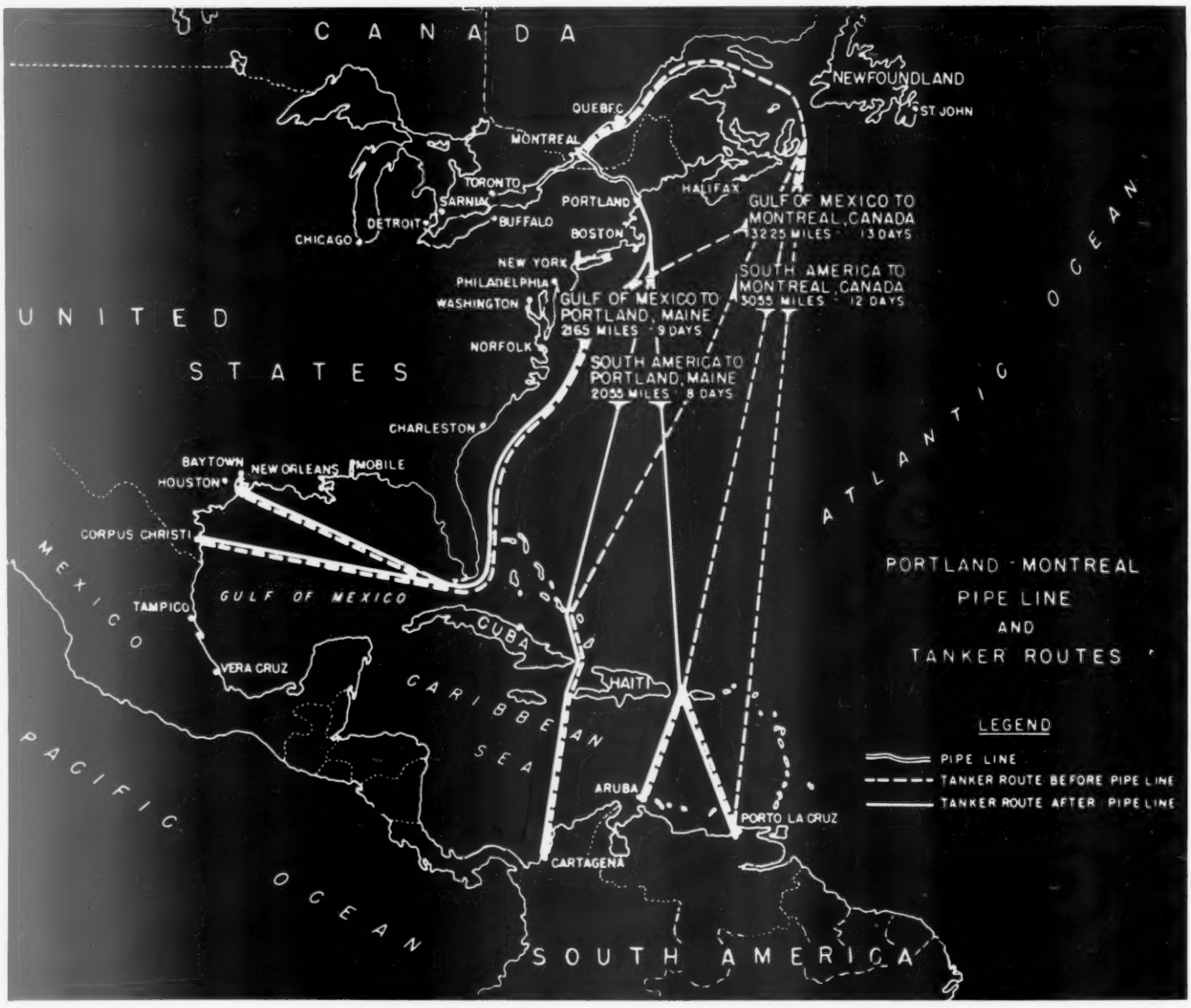
*Chief Engineer, Portland Pipe Line Corporation.
†Director of engineering, Mason-Neilan Regulator Company.

The Portland-Montreal pipe line was constructed during 1941 as a defense measure to provide year-round deliveries of crude oil to the four refineries at Montreal. Previously these refineries received deliveries direct by tanker during seven months only, as the St. Lawrence River is ice-bound during the five winter months. The pipe line eliminates an approximately 2000-mile round trip by tanker, which was particularly important during the war when there was a shortage of ships and the German submarines were very active along the eastern seaboard.

The main line is a welded line 12 in. in diam. constructed of seamless pipe having a wall thickness of 3/8 in. The total length of the line is 236 miles with 166 miles in the United States, crossing Maine, New Hampshire, and Vermont, the remaining 70 miles passing through the Province of Quebec from the international border at North Troy, Vermont, to Montreal.

The Portland-Montreal pipe line was financed and constructed by the Standard Oil Company (New Jersey) through subsidiary companies. The Portland Pipe Line Company, a Maine corporation, owned and operated the United States end of the line and the Montreal Pipe Line Company, Ltd., a Canadian corporation, owned and operated the Canadian end of the line. Deliveries are made to the refineries at Montreal of The British American Oil Company, Ltd., McColl-Frontenac Oil Company, Ltd., Imperial Oil, Ltd., and the Shell

FIG. 1. Tanker and pipe line routes to Montreal.



TULSA STOCK includes (from left to right) Worthington HR Centrifugal Refinery Pumps, CF pumps, rotary pumps, standard steam pumps, and Hivol steam pumps. Convenient stock of HR's also in Los Angeles, as well as a "general line" stock in Houston.

Now in field stock . . .

HR Centrifugal Refinery Pumps

This is the pump that is standard equipment in leading refineries the world over—and Worthington has plenty of them.

Because it is "made to order" for refinery processing, *right* in every single detail, the HR Centrifugal Pump is carried in stock.

With adequate stocks of the hard-working HR on hand—not only in Tulsa, but also in Los Angeles—Worthington can offer fast, efficient service on emergency replacement or changeover requirements.

We invite you to take advantage of this opportunity to secure an HR Centrifugal Pump right from stock.

For further information proving *there's more worth in Worthington,* contact our nearest District Office. Or write to Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N. J.

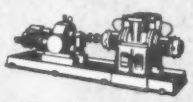
MEMBER HYDRAULIC INSTITUTE

WORTHINGTON

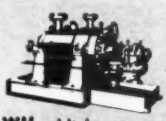
THE WORLD'S LARGEST MANUFACTURER OF PUMPS

C7-16

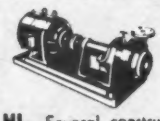
Types HR and HB. Twenty sizes. Capacities up to 1800 g.p.m. Developed heads up to 900 ft. Proper selection of material permits use for temperatures far below zero to 800°F., for pressures from high vacuum to 750 lb. per sq. in. gauge.



Type HD. Hydraulically-balanced, double-suction impeller handles boiling liquids with low submergence. Capacities range from 600 to 3200 g.p.m. at heads up to 700 ft., temperatures up to 850°F., pressures up to 550 lb.



Type WH. High-pressure, high-temperature, centrifugal hot-charge pumps. Twelve distinct points of superiority, based on years of experience building pumps for high pressures and temperatures. Capacities to 2000 g.p.m., heads to 5000 ft.



Type HL. Several construction arrangements permit flexibility in application. Designed for temperatures up to 225°F., or higher with water-jacketed stuffing box. Capacities up to 1600 g.p.m., heads to 500 ft.

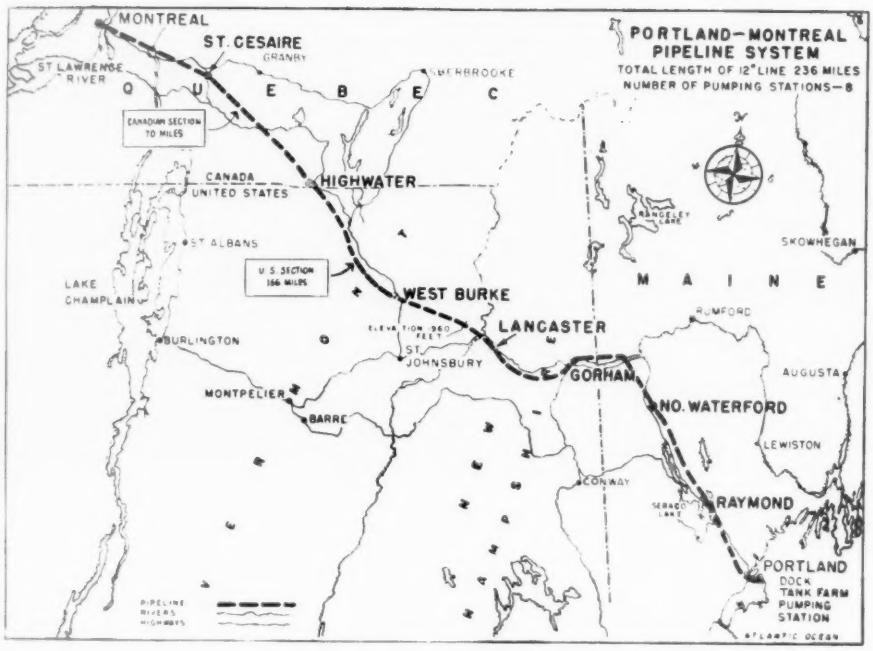


FIG. 2. Booster station locations.

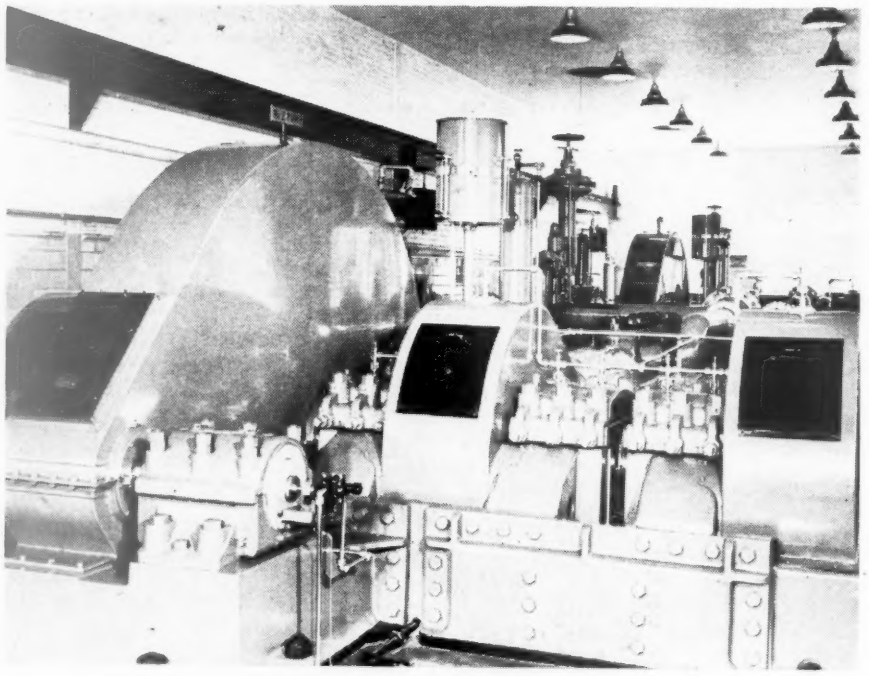


FIG. 3. Pumps at Raymond station.

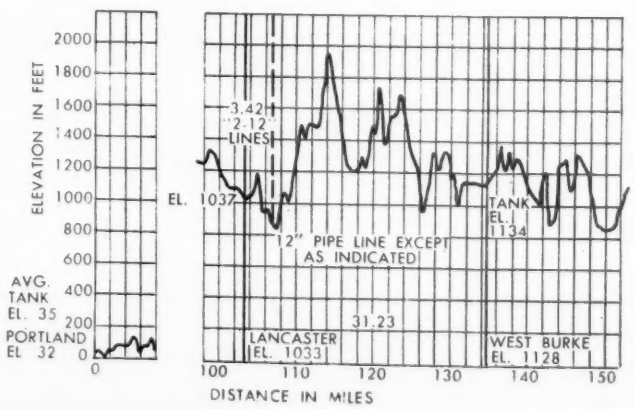


FIG. 4. Hydraulic gradient between the stations at Lancaster and West Burke.

Oil Company of Canada, Ltd. In April, 1946, the Standard Oil Company (New Jersey) sold its entire interest in the system to these four Canadian companies and at that time the four companies formed a new Maine corporation, the Portland Pipe Line Corporation and took over the assets and operation from the Portland Pipe Line Company.

Crude oil is delivered by tanker at the new steel and concrete unloading pier at South Portland, Maine. This pier accommodates two tankers at one time and unloads up to 15,000 bbl of crude an hr. Tankers are unloaded either through a 24-in. line, approximately three miles long, to the tank farm where the first main line pump station is situated, or through a 16-in. line to two storage tanks on shore. Oil unloaded into the two shore tanks is later transferred with centrifugal pumps at the unloading station to the tank farm through the 24-in. line. Combined storage capacity of the waterfront terminal and the tank farm is a little over 1,100,000 bbl.

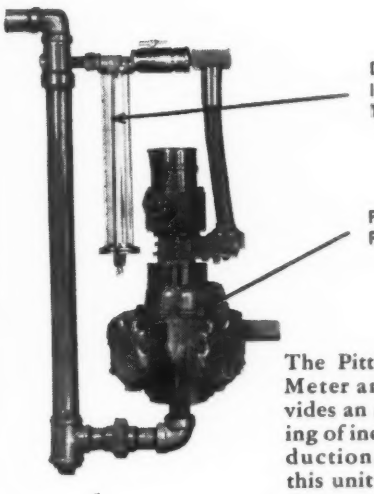
There are seven booster stations along the line besides the inital station, spaced about 30 miles apart. These stations handle up to 70,000 bbl. of crude oil a day, discharging at a maximum pressure of 800 psi into the main line. Portland receives oil from 14 or 15 different fields in South America and Mid-Continental United States, and the crude batched through the Portland-Montreal pipe line has a wide range of characteristics. During the war the line carried several emergency batches of aviation gasoline but now handles only crude oils. Gravities range from 19 to 47 deg. API, and viscosities from 34 to 1500 SSU (Cumarebo to heavy Colombian). In some instances crudes with a very high wax content are blended to lower the pour point, and in other cases high viscosity crudes are cut back with casinghead gasoline to improve their pumping characteristics. Crudes of this nature present a problem more or less peculiar to the Portland-Montreal pipe line. This line was an adventure with low temperatures. Atmospheric temperatures in some locations drop to 50 F below zero in winter, and oil temperatures in the line drop to 33 F above. During the winter months a maximum allowable pour point of 20 F is maintained to avoid the possibility of the oil in the line going solid if there should be a forced shutdown with a resulting temperature drop in the line. Should this happen, it is probable that the system would be shut down until the following spring. All outside work on the line is done during the summer, as the ground is frozen solid in winter and can be broken only with a pneumatic drill or a "concrete buster." Pipeliners out in the heavy snow have to carry skis or snowshoes, emergency food rations, extra clothing and blankets and a host of special winter automobile accessories.

Of the eight mainline pumping stations, six are electric and two are diesel (where electric power supply facilities are inadequate). The motors are Electric Machinery Manufacturing Company in the U. S. and General Electric in Canada. They are synchronous, unity power

HOW TO KEEP YOUR FINGER ON PETROLEUM'S PULSE FROM WELL-HEAD TO REFINERY

Now it's easy to keep tab on the all-important quality and quantity phases of crude oil production and distribution. For with the accurate records provided by the Pittsburgh samplers and meters described below, petroleum producers have at their fingertips the controls that will assure maximum revenue from their operations.

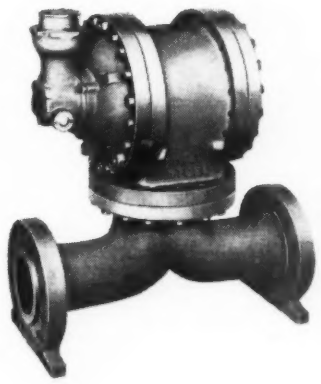
KNOW THE TRUE QUANTITY OF CRUDE PRODUCED



The Pittsburgh Oil Field Meter and Sampler provides an accurate accounting of individual well production. Simply install this unit on the line from the separator. The Pittsburgh Piston Meter then accurately measures all liquid produced. The Sampler automatically and at predetermined intervals takes a true composite sample of the metered mixture of oil and water. The percentage of oil produced is determined by direct reading from the graduated Sampler tube. This figure applied to the total meter reading establishes the true degree of well production. *Ask for bulletin OG-350.*

PITTSBURGH *Oil field* METER AND SAMPLER

KNOW THE TRUE QUANTITY OF CRUDE DISPATCHED TO MARKET



Rotocycle meters installed on the outlets from tank storage accurately measure the total production from any field. They are also used to measure the entire throughput in a pipe line system. These meters are engineered and built to stand up under the most difficult conditions. They are available in three sizes for either high or low pressure service and may be fitted with a variety of registers to suit any field requirement. *Ask for bulletins OG-146, 147, 148, 149, 150 and 151.*

PITTSBURGH ROTOCYCLE PIPE LINE METERS

PETROLEUM METERS & ACCESSORIES

PITTSBURGH EQUITABLE METER DIVISION
ROCKWELL MANUFACTURING COMPANY · PITTSBURGH 8, PA.
Atlanta, Boston, Chicago, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco, Seattle, Tulsa

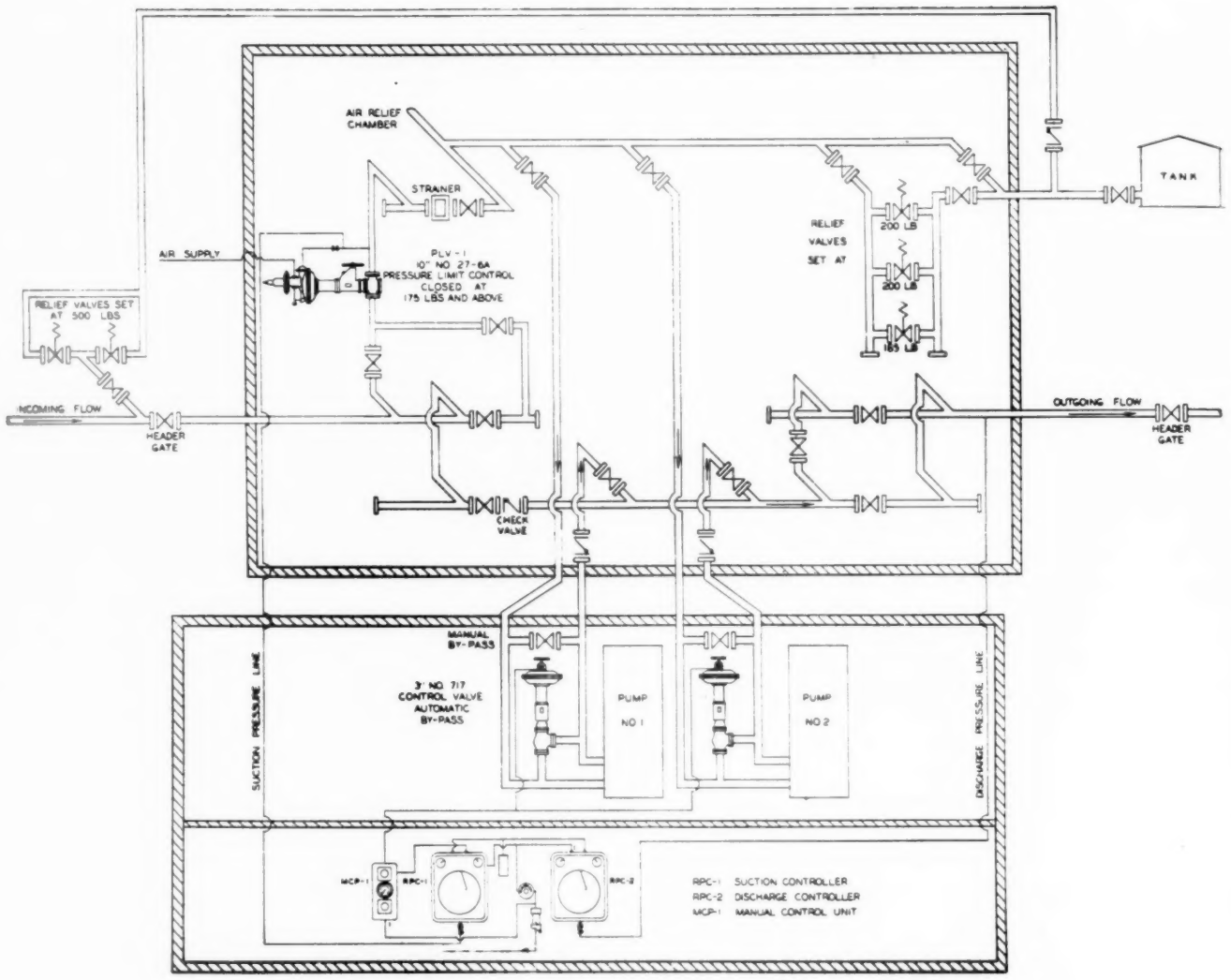


FIG. 5. Control system at four booster stations

factor motors (with the attendant economies) rated at 500 hp, 327 rpm, 2300 volts. Of the diesels at the other two stations, two are 16¼-in. by 23-in. 4-cycle, 6-cylinder heavy duty straight Busch-Sulzer engines for 600 hp at 225 rpm, and two are McIntosh-Seymour engines for 500 hp at 225 rpm. Pumps are positive displacement, triplex double-acting plunger type. Fourteen are Goulds 6¾ in. by 27 in., two are Prescott 7⅛ in. by 24 in. Fireproof walls with stuffingboxes for the shafts separate the pump rooms from the prime movers.

● **Operation of open system under manual control.** Originally, this line operated as an "open" system. A 30,000-bbl over-and-short tank at each booster station floated on the line. An 8-in. back pressure regulator maintained the suction pressure to the pumps at or below 20 psi. If the pumps could not handle the full throughput of a preceding station, the suction pressure would rise, partially opening the regulating valve and shunting the excess oil flow to the tank. The tank would then take on oil until the regulating valve closed again, after which the contents of the tanks would remain constant or would flow back through a check valve to the pump suction, if the suction pressure declined below the static tank head. The valve was large enough to route the full stream to the tank in case of station shutdown.

Operators formerly controlled station pumping rates by hand-operated plug valves on bypasses between the pump discharge and suction headers.

This manual control system required constant attention by the station operators to maintain an even pumping rate, and it was the study of this problem that led eventually to the adoption of the new control system.

The elevation profile of the territory through which the pipe line operates is such that between certain pump stations there are critical points, especially at the slower pumping rates. It can be seen that this condition would cause line surges and to alleviate this the station operators would adjust the pump bypass flow in order to reduce pump pounding and smooth out the pumping rate.

Also, the manual control system augmented the work of operators and dispatchers. The operator frequently had to adjust the hand lever operated plug valves on the pump bypasses up to a dozen times per shift as his dispatcher directed. Every time an operator changed his bypass setting it would throw off all other stations, forcing them to readjust their pressures, and so on up and down the line. This gave the flow a long-term cycling effect. The operator had to observe his pressure records carefully and relay the data to the dispatcher, who would try to correlate the records of all stations and direct the operators accordingly. With the tanks in use the operators had to go outdoors and gauge the tanks hourly even in the roughest weather.

Another problem, and probably the most important of all, was contamination. With as many as three different tenders of varying grades in the 236-mile line at one time, the over-and-short tanks would be intermittently mixing one grade of crude with another. There was no positive way to eliminate contamination with the station tanks on the line, although by careful operation it was kept to a minimum. This condition was particularly serious with lube stock being batched through, as any contamination seriously affected the refinery operation.

Whether it's

Big Valves

like this - - - - - - - - - - - - -

or

Little Valves

like this - - - - -

- - - - - If they're *STEEL* valves, and if the economies of greater flow, lower pressure drop and less wear-producing turbulence are important to you . . .

The valves you want are *Edward*

Edward builds a complete line of steel valves for all pressures and temperatures for boiler room, petroleum, marine, industrial and technological services.

Edward Valves — The line of least resistance to flow.

Edward Valves, Inc.
SUBSIDIARY OF ROCKWELL MANUFACTURING CO
EAST CHICAGO, INDIANA

The remedy for this was to operate as a closed system and do away with the over-and-short tanks.

These, then, were the reasons for the changeover to automatic control: (1) To stop contamination of the various grades of crude oils, (2) to maintain a controlled suction pressure to the pumps, (3) to limit the maximum discharge pressure, (4) and to simplify the operators' and dispatchers' work.

● **Operation under automatic control.** The purpose of a pipe line is to transport oil economically. Automatic control must improve this transportation if it is to justify the initial and maintenance expense. Analyzing the requirements, it is desirable first to separate the functions best performed automatically from those that by design and operation of the pipe line are more simply and smoothly performed by manual adjustment. Bear in mind that the complications necessarily added by the automatic control system must be justified by the superior performance.

Except in few highly specialized pipe line installations, operators must be in attendance at all stations. The responsibility for overall operation always remains in the hands of the operators. The control system and the control mechanisms, therefore, have to be relatively simple so that the station personnel, whether regular or relief, can handle all ordinary operations and maintenance. The controls must be usable tools to assist the operator in performing functions far better than he can do with manual means. They should relieve the operator of the jobs that require continual tiresome adjustments.

● **Description of the control system.** The system chosen for automatically controlling the Portland-Montreal pipe line is based on series operation of the suction and discharge controllers. This basic method has been used by a number of pipe lines, handling both refined products and crude, with the details of the equipment, installation, and operation modified to meet local conditions.

This control system and its individual elements is illustrated by Figs. 5 and 6.

Control valves: The 3-in. angle-type air-to-close control valves are installed in cross-over lines between the suction and discharge headers. These are two valves at each station, one for each pump. These provide for suction and discharge pressure control on either or both pumps.

The valve has a diaphragm motor pressure range of 3 to 15 psi. That is, the valve is open until the controller output air pressure increases to 3 psi, when it will begin to close. Further pressure increase progressively closes the valve until at 15 psi it is shut. Increased air pressure to the valve tends to close the valve, reducing the bypass flow around the pumps, *increasing* the flow through the station.

Low limit suction pressure control. The measuring element of the suction controller measures the suction of the station. The predetermined control point is set at about 25 psi or more depending on the conditions at the individual station. The output air pressure of the discharge controller is the air pressure supply to the suction controller.

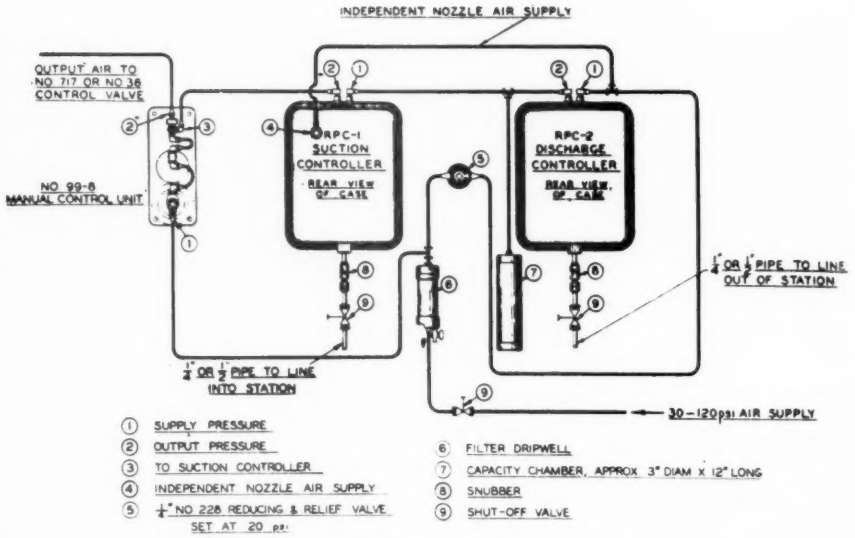

INDEPENDENT NOZZLE AIR SUPPLY
OUTPUT AIR TO NO 717 OR NO 36 CONTROL VALVE
NO 99-B MANUAL CONTROL UNIT
RPC-1 SUCTION CONTROLLER
REAR VIEW OF CASE
RPC-2 DISCHARGE CONTROLLER
REAR VIEW OF CASE
¼" OR ½" PIPE TO LINE OUT OF STATION
¼" OR ½" PIPE TO LINE INTO STATION
30–120psi AIR SUPPLY
① SUPPLY PRESSURE
② OUTPUT PRESSURE
③ TO SUCTION CONTROLLER
④ INDEPENDENT NOZZLE AIR SUPPLY
⑤ ¼" NO 228 REDUCING & RELIEF VALVE SET AT 20 psi
⑥ FILTER DRIPWELL
⑦ CAPACITY CHAMBER, APPROX 3" DIAM X 12" LONG
⑧ SNUBBER
⑨ SHUT-OFF VALVE

FIG. 6. Showing series operation of controllers

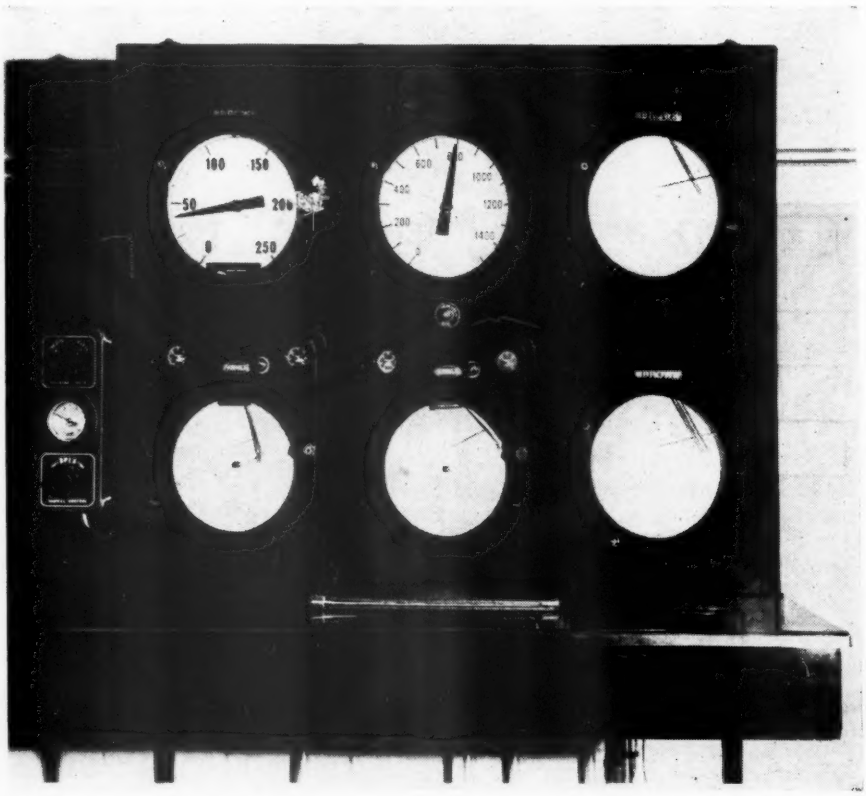
Assuming that the discharge pressure is below the control point of the discharge controller (about 800 psi), the output pressure of this controller is always the same as its air supply pressure—in effect, the discharge controller is by-passed. When the suction pressure is greater than 25 psi, the output air pressure of both suction and discharge controllers is 15 psi; therefore, the control valve is shut.

If the suction pressure begins to drop below 20 psi, the suction controller immediately reduces the air pressure to the 3-in. angle valve. This opens the valve when the air pressure is below 15 psi, thus bypassing back to suction some of the outbound oil flow.

The range of the recording and controlling pressure instrument is 0 to 250 psi, with protection for 100 per cent overload or to a total of 500 psi.

High limit discharge pressure control. The measuring element of the discharge controller measures the discharge pressure. The predetermined control point is set at about 800 psi.

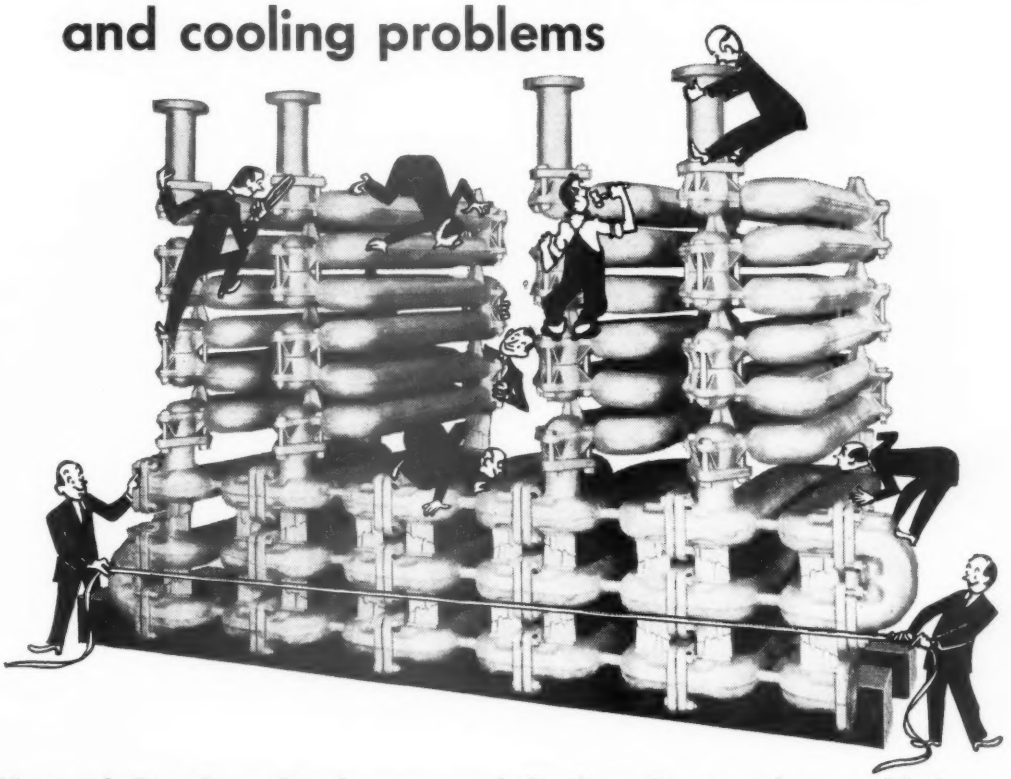
FIG. 7. Control panel at a typical station.



Investigate

NATIONAL SECTIONS

for the answer to your condensing and cooling problems



National Cast Iron Condensing and Cooling Sections have sold themselves to many satisfied customers over a period of years by meeting the following basic requirements of process equipment:

1. PERFORMANCE
2. DURABILITY
3. SIMPLICITY
4. ECONOMY

Please consult with us on your future condensing and cooling requirements. Write for our Catalog CP-16.

INDUSTRIAL DIVISION

The National Radiator Company

221 CENTRAL AVENUE . . . JOHNSTOWN, PENNSYLVANIA

Assuming that the output air pressure from the suction pressure controller is 15 psi, the output air pressure from the discharge pressure controller is also 15 psi so long as the station discharge pressure is below the control point of 800 psi. Therefore, the valve is shut.

If the station discharge pressure begins to exceed 800 psi, the discharge controller immediately decreases its output air pressure to the control valve. This increases the bypass flow to suction, limiting the station discharge pressure to 800 psi.

Series operation of the suction and discharge controllers. Either the suction or discharge controller may govern the actual opening (exposed area) of the control valve, but never both at the same time. The maximum air pressure to the control valve diaphragm is 15 psi. Either controller can reduce this pressure, and the controller that establishes the lower output air pressure governs the valve opening.

Independent nozzle air supply pressure on suction controller. When the discharge controller comes into operation, the control mechanism of the suction controller is completely bypassed. At this time the output pressure from the discharge controller is the only supply pressure available for the pilot and nozzle. If the output from the discharge controller is below 10 psi the nozzle and pilot operation is sluggish; below 7 psi, they are inoperative. Therefore, an independent nozzle air supply of 20 psi is brought to the suction controller.

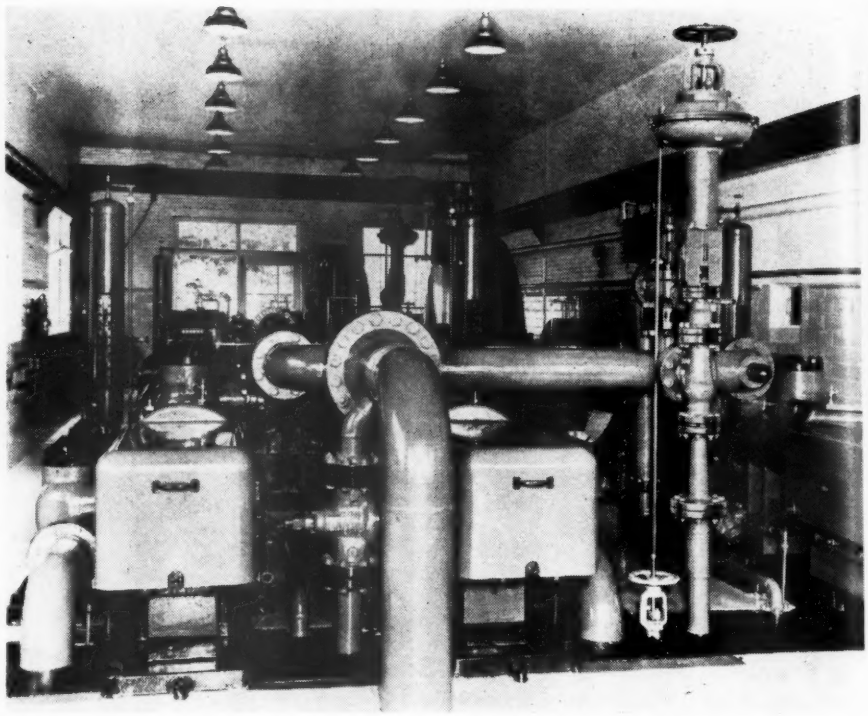


FIG. 8. Control valve in cross-over line between suction and discharge headers.

FIG. 9. Pilot-operated back pressure regulator protects pump suction manifold.

● **Operation of the Portland pipe line control system.** The major functions of the control system are to:

1. Set and maintain within limits the throughput of the initial station at Portland.
2. Adjust the individual booster station pumping capacity to the throughput of the initial station at Portland.
3. Limit the minimum booster station suction pressure (inbound).
4. Limit the maximum booster station suction pressure (inbound).
5. Limit the maximum station discharge pressure (outbound).

The originating station at Portland sets the discharge control to maintain an optimum constant discharge pressure. This determines the pipe line throughput. Under constant operating conditions a fixed discharge pressure will hold the flow constant. Variation in flow results when tenders with different viscosities are introduced. The change in flow from one tender to a second tender is gradual as the first tender becomes displaced in the line. The discharge controller gives the operator a simple means of setting the precise discharge pressure and the line throughput.

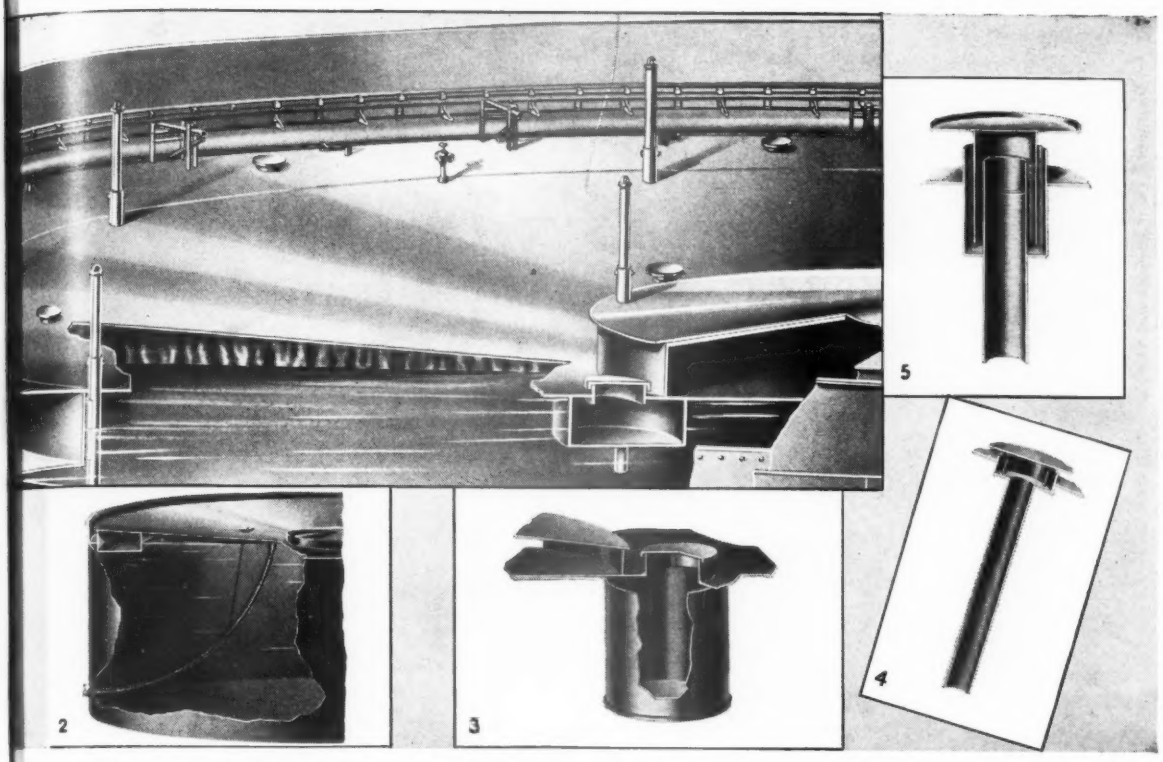
Unless operating conditions are such that there is a bottleneck at some booster station, all stations normally operate on suction control. When the suction pressure is held constant, the booster station pumps out all that comes into it. If the flow entering a station increases, the suction pressure tends to increase and the controller further throttles the valve (Fig. 8) in the bypass around the pump. This increases the station pumping capacity to match exactly again the quantity entering the station. Thus, any change in throughput made at Portland causes all booster stations to adjust their pumping capacity to match. This is the only way a closed system can operate.

Holding the suction pressure to a minimum permits the line to operate at the lowest static pressure permissible with the line throughput. The suction pressure must be held to a positive value for the pump to fill properly on the suction stroke, otherwise pounding results. The suction pressure at various stations is frequently set at different values, depending on the hydraulic gradient of the line entering the station.

In order to protect the pump suction manifold against high static pressure a 10-in. pilot-operated back pressure regulator (Fig. 9) functions on the suction line to the pump. This regulator is set at 175 psi and so long as the pressure is below 175 psi the valve is wide open. If the suction pressure tends to exceed 175 psi, the regulator closes as required to prevent further pressure increase. When the incoming line pressure exceeds 185 psi the relief valve opens, relieving to tankage.

The discharge controller setting establishes the maximum discharge pressure. When the pressure tends to increase beyond this setting the discharge controller opens the pump bypass valve as required to limit the pressure.

● **Selection of type of control equipment.** In selecting the type of controller to be used, the major considerations were ruggedness and simplicity. Both the suction controller and the discharge controller are proportional controllers, without reset. The use of reset would permit



1—Steep Deck Slope 2—Hose Drain 3—Tipping Pontoon 4—Overflow Drain
5—Emergency Siphon Drain

INSURE PROPER DRAINAGE

The steep deck slope, only obtainable in Wiggins Roofs, is one of the most important advances made in floating roof design. Combined with the new and ingenious drainage fittings—shown above—a Wiggins Hidek Floating Roof is a guarantee of safe operation under all conditions of water load.

Other exclusive features of Wiggins Hidek Floating Roof design include — Triple Seal Protection — Breathing but no Venting—Large Pontoons—for easy and quick inspection—all are illustrated through the medium of three dimensional phantom drawings in the new bulletin on the press.

Write for a copy today.

WIGGINS BALLOON ROOF

WIGGINS BREATHER ROOF

WIGGINS DRY SEAL LIFTER ROOF

WIGGINS DRY SEAL GAS HOLDER

WIGGINS VAPOR SEALS GATX GENERAL AMERICAN

General American
TRANSPORTATION CORPORATION

135 SOUTH LA SALLE STREET, CHICAGO 90, ILLINOIS

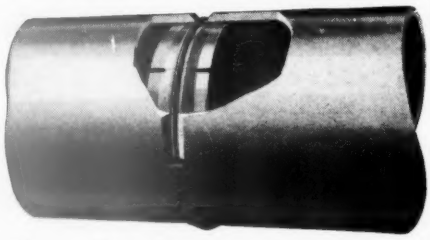
BRANCH OFFICES: New York • Washington, D. C. • Cleveland • Buffalo • Pittsburgh
St. Louis • New Orleans • Tulsa • Dallas • Houston • Seattle • Los Angeles • San Francisco

SUB-LICENSEES:

WESTERN STATES: Consolidated Steel Corp. — Western Pipe & Steel Co. of California, Los Angeles — San Francisco
SOUTHERN STATES: Wyatt Metal and Boiler Works, Houston — Dallas, Texas
FRANCE: Etablissements Delattre & Frouard reunis, Paris
CANADA: Toronto Iron Works, Ltd., Toronto

Get STRONGER REFINERY and PIPE LINES— by Welding with WEDGE Split CHILL RINGS

Because you can REINFORCE joints by using WEDGE Chill Rings with the patented SPLIT Feature, it is possible to use THIN WALL pipe and save time, labor and material. WEDGE Chill Rings REINFORCE the joints, making



them the strongest part of the line—so strong that under shock, strain or vibration, the pipe will fail before the joints. Great savings are being made with this improved welding method. It will pay you to investigate.

Write for Information

WEDGE PROTECTORS, INC.

3977 Jennings Road, Cleveland 9, Ohio

WEDGE Split CHILL RINGS SAVE MONEY

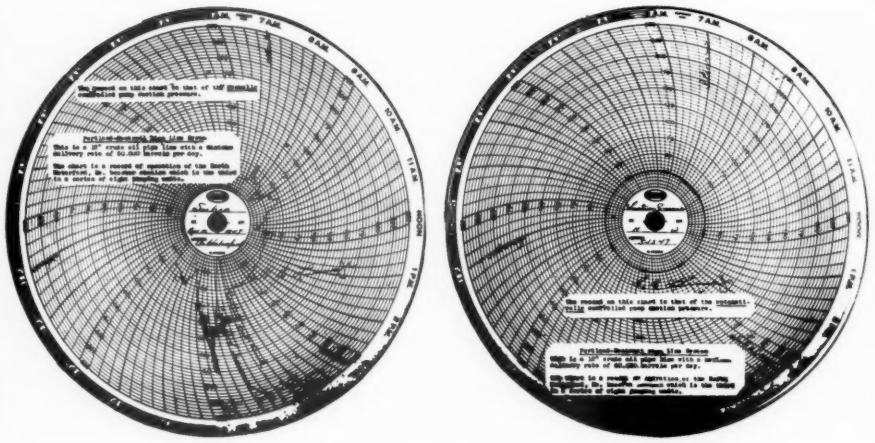


FIG. 10

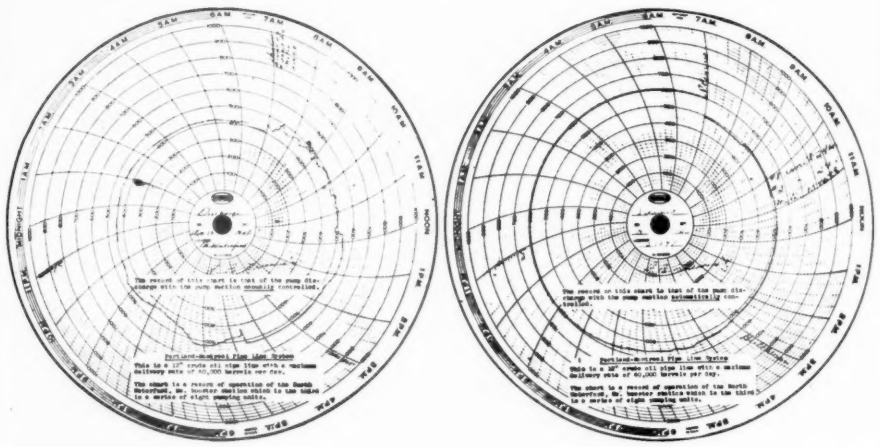


FIG. 11

FIG. 10. Suction pressure records; *Left*, manual control; *Right*, automatic control (closed system).

FIG. 11. Discharge pressure records: *Left*, manual control; *Right*, automatic control (closed system).

a constant control point under load change where the proportional controller allows the control point setting to vary, and the setting index does not always indicate the exact control point. Reset was avoided as its disadvantages outweighed its advantages. First, it adds complication in requiring two stabilizing adjustments instead of one. So far as line operation is concerned, it is important that the controller level out the pressure and flow following any change as quickly and smoothly as the pipe line system will permit. Rocking the line and nursing pressure waves should be avoided. It is true that with proper adjustment of the reset rate (very slow rates) stability can be achieved with reset. With stations spotted from Portland across the border into Montreal, however, it seemed impractical to introduce the intricacies of reset into isolated stations where skilled instrument service would be very hard to get.

The major reason for not using reset, however, is that the suction and discharge controllers are interlocking controllers operating the same control valve (see Fig. 5). In operation either the suction or the discharge controller positions the bypass control valve. The controller that is not operating the valve is bypassed with either full supply pressure or the diaphragm pressure equalized in the reset control system. If operating conditions then require the controllers to swing from suction to discharge control or vice versa the position of the proportional band may be at any location with respect to the setting index, and appreciable deviation in pressure may result until the reset has had time to balance out the control point. The proportional controller has the advantage that the proportional band remains fixed with respect to the setting index. Its operation is never discontinuous, which is not true of a reset controller balanced at a 20 psi supply pressure when the control valve is fully closed at 15 psi.

The only way to vary the capacity of large constant speed positive displacement pumps is to bypass the flow from the discharge header to the suction header. This is a pretty tough control valve application. The required valve capacity is large and the pressure drop across the valve is appreciable. The normal dis-

Wherever there's oil—

. . . there's a local supply store handling MARSH GAUGES

MARSH ALONE HAS THE "RECALIBRATOR"—quickest and most satisfactory way to correct a gauge that has been knocked out of adjustment through improper handling.

Marsh branch plant at Houston offers shipment from stock, facilities for repairing all gauges

• Wherever you are, there's a supply of Marsh Pressure Gauges nearby. We have not only developed pressure gauges for every phase of the petroleum industry, we have also made them available wherever oil is produced, transported or refined. To further expedite distribution and service in the oil country there is a Marsh branch plant at Houston with complete facilities for servicing all makes of pressure gauges.

The harder you are to please, the better you will like these gauges that are engineered down to the last detail for every service encountered in the oil industry. In the Marsh Mastergauge you have an instrument guaranteed accurate within ½ of 1% of reading—a gauge with a finer monel and stainless steel movement, lathe turned bourdon tube and moistureproof, vaporproof case—a gauge that sets a new standard for quality and stamina.

The Mastergauge is made in types for every application—as a Christmas tree gauge, an oil country boiler gauge, and with effective diaphragm protection as a mud pump gauge. The line includes the finest of hydraulic gauges and Reid Vapor Test gauges. Ask for new oil industry bulletin containing convincing facts about Marsh Gauges.

JAS. P. MARSH CORPORATION, Department M, Skokie, Illinois.

"THE STANDARD OF ACCURACY"

charge pressure is 600 to 800 psi. The normal suction pressure is 25 psi. The pressure drop across the valve is thus 575 to 775 psi. The control valve employed (Fig. 8) is a 3-in. angle-type valve with heat-treated stainless steel trim, hardened to a Brinell of 500 or a Rockwell C of 50. The handwheel shown on the diaphragm motor is for setting the opening of the valve manually. The 3-in. valve has a reduced area port, and is chosen to give a maximum of 25,000 bbl per day at 600 psi pressure drop in the full open position.

Cavitation is one of the serious problems met with when control valves operate on liquid service under high pressure drop. Excessive erosion in valve body trim and adjacent piping mark the cavitation condition, and in this case there was also a rumble and vibration with unbearable noise. Extensive experimental work was done in the hydraulic laboratory and at the booster stations to determine the valve plug contours and the piping arrangement to produce a quiet and satisfactory valve for this service.

● **Performance of pipe line under automatic control.** Six months of operation under automatic control show results that are most satisfactory. The charts in Figs. 10 and 11 contrast pressure records made under automatic control with those taken from manual control of the closed system.

The charts in Fig. 10 are records of the suction pressure at the North Waterford station. Chart dated April 13 is a record showing manual control with the pipe line operated as a closed system. Manual control meant adjusting the position of the plug valve in the bypass around the pump, based on constant observation of the suction pressure. Chart dated May 13 is a record of suction pressure under automatic control.

Fig. 11 shows records of the discharge pressure with the station under manual control and under automatic suction control. Notice how the discharge pressure under manual suction control varies, reflecting the pattern shown in the suction record. The discharge on automatic pressure control again reflects the general characteristics of the suction pressure, indicating smoothness in line operation. The gradual increase in discharge pressure beginnng at 9 a.m. is the result of a change in tender.

The dispatcher's work is now much pleasanter. His problem is to direct the output of South Portland, the initial pumping station, so that the station of least capacity can handle the throughput while there is minimum energy loss through throttling valves in the system. To cut back on the throughput, the initial station merely resets the control point of the discharge pressure controller to a lower valve, and does the same during transition from a high viscosity to a low viscosity tender.

With this system the over-and-short tanks will serve during scraper operation. About every two to three weeks the scraper is started through the line, and the tank at the next station goes on the line just before its calculated arrival. The tanks at the first two booster stations are connected to relief valves on the incoming line, so that in case the suction pressure exceeds 185 psi, the crude oil flows to the tanks. Should either of these stations have a shutdown, the incoming stream is bypassed to the next staton, with a decrease in throughput of approximately 33 per cent. The tanks are now blocked off and serve only as insurance in case of emergency.

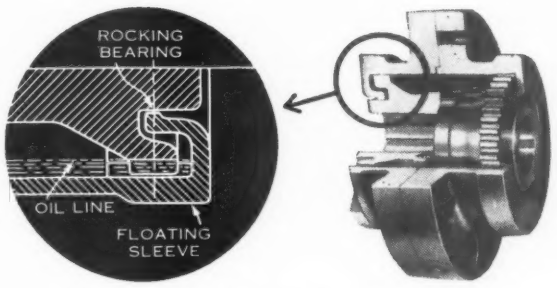
One expects that the pipe line management and engineers would approve a control system such as this because they can recognize the overall advantages in it and see that uniformity of operation pays off; however, engineers do not have to operate the booster stations, do not experience the strained watchfulness, physical exertion, or exasperatng repetition of movement necessary to manage a station under manual control or under a poorly integrated automatic control system. Nor do they have to cope with the maintenance and adjustment of a highly complex control system. The station operator is the man who lives with the control system, and his independent opinion of its operating merits has an importance all its own. When the new control system was first put in, the Portland pipe line operators were somewhat skeptical, but after a short period they found the automatic control to be a practical working system. ★★★

BITURINE, or other high grade coatings are products of modern chemical engineering skill; their protective qualities against electrolytic or all corrosive actions are the result of chemical research.

HILL, HUBBELL pipe protection, mechanically applied indoors, assures the positive effectiveness of good coatings. HILL, HUBBELL thorough pipe cleaning, temperature controlled priming and hot coating—and—wrapping, give you the maximum in modern pipe protection.

For TIME enduring pipe protection specify the H & H process.

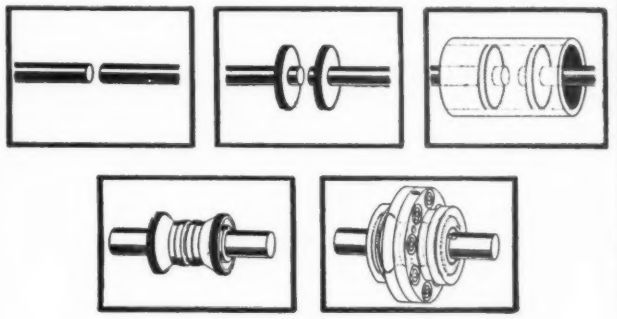
Hill, Hubbell and Company
Division of GENERAL PAINT CORPORATION
3091 MAYFIELD RD. CLEVELAND, OHIO.



HERE'S HOW FAST'S Eliminates Perishable Parts!

No matter which type of Fast's Coupling you use, you can be sure of this . . . it will be all-steel throughout . . . without a single perishable part! As an example, the exclusive "rocking bearing," shown above, provides a positive metal-to-metal seal to protect the load-carrying oil against moisture, dust and grit. No perishable packing rings are used. There's nothing to wear, nothing to fail.

1

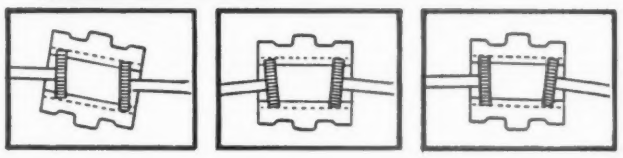


HERE'S HOW FAST'S Are Constructed— Simple as A-B-C!

See the simple development of Fast's self-aligning Couplings. A splined hub on each shaft end. A sleeve with internal splines to mesh. Oil in the sleeve, kept between the splines by centrifugal force, carries the load between the splines.

2

These Facts About the ORIGINAL Gear-Type Coupling *Can Save You Costly Coupling Shutdowns*



HERE'S HOW FAST'S COUPLINGS Compensate for Misalignment!

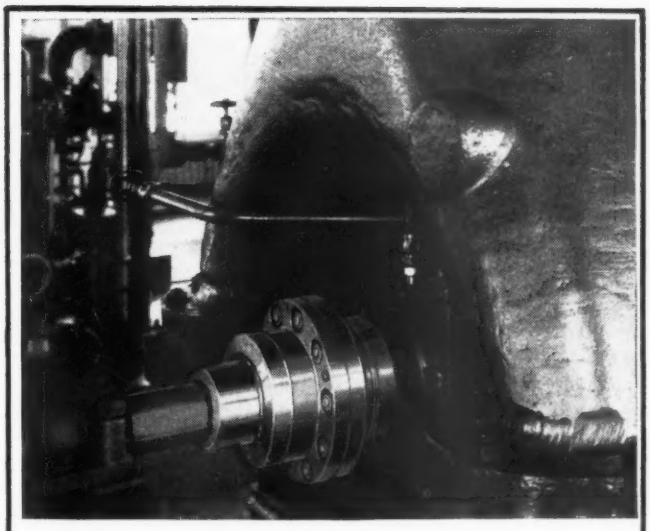
The floating sleeve takes a neutral position. All forms of misalignment are compensated for between the lubricated faces of the splines, equally divided between the driving and driven members. The entire assembly revolves as one unit.

3

WE HAVE *a complete line of couplings for immediate delivery. Get full details on Fast's Couplings now by writing for our complete catalog. Just drop a line to:* Koppers Co., Inc., Fast's Coupling Dept., 322 Scott St., Baltimore 3, Md.

KOPPERS

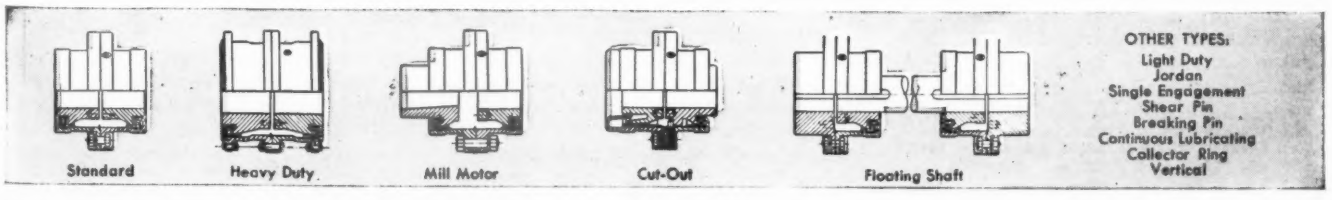
FAST'S *self-aligning* COUPLINGS



HERE'S HOW FAST'S COUPLINGS ARE USED

This Fast's Coupling connects a turbine and lean oil pump at Chicago Corporation, Carthage, Texas . . . another application where uninterrupted power transmission is of top importance. When you buy Fast's Couplings, you buy many years of top engineering experience, Koppers' high standard of workmanship and unexcelled coupling service. Result: longer machine life, lower upkeep costs, minimum shutdown losses.

4



Design and construction of compressor plants*

By PAUL D. TORREY[1], *Consulting Petroleum Engineer*

● **Abstract.** This paper considers the design and construction of plants for the compression of air and gas to be injected into partially depleted reservoirs for the purpose of increasing the recovery of oil. Most gas or air repressuring projects are on a small scale compared to the large compressor plants employed for pressure maintenance in new fields.

Preliminary tests, under competent engineering supervision, are essential for the selection of compressor facilities having adequate capacity for the repressuring program. Lack of sufficient natural gas may require the use of air for repressuring which will result in corrosion problems as well as produce hazards from possible explosions.

Compressors commonly used in repressuring operations are of the reciprocating type and are usually double acting. Formulae are presented for determination of brake horsepower requirements and for the volumetric displacement of the compressor cylinder. The need for close control of engine fuel and for consideration of the supercompressibility factor are emphasized. A formula for calculating the efficiency of compressors is presented and it is shown that if the ratio between intake and discharge pressure is much greater than from 4.5 to 5 two stages of compression should be used.

Adequate sized pipe connections for intake and discharge are essential for efficient compressor performance. A graphical method for determination of average momentary flow rate for a compressor cylinder is presented.

An efficient cooling system is essential for trouble-free and low-cost compressor operation. The volumes of water required to maintain certain temperature differentials between intake and outlet water for a thousand horsepower plant are listed, and plans for a dual cooling system are described and illustrated.

Specifications for quality of cooling water are given and methods of water treatment in common use are described. Poor cooling water will result in deposition of scale or in corrosion, or, frequently, both troublesome effects. Film inhibitors of various types are receiving increased attention for certain types of scale formation and corrosion. Growth of microorganisms must be controlled by chemical treatment. Various alkaline compounds used for water treatment may have a very detrimental effect on the wood used in the construction of cooling towers. Methods for combating this harmful effect are reviewed.

The removal of dust from both air and gas in areas where dust storms prevail will reduce wear on moving parts in both the engine and compressor cylinders to a minimum. Cooling and filtration of lubricating oil will preserve it in good condition for months of continuous service.

Safety devices to prevent overheating and to protect against explosions are necessary equipment for compressor plants used in air and gas repressuring operations.

The types of building commonly used for compressor plants are described. The vertical, angle-type of gas engine-driven compressor has had excellent performance records and is being rather generally adopted for new installations. Benefits of operating compressors below rated capacity are cited.

Cooperation with the compressor manufacturer in the design of plant layout is desirable, and proper attention should be given to plant foundations.

● **1. Introduction.** In a majority of the fields where gas is being introduced into the producing formation to stimulate the production of oil there is no source of high-pressure gas occurring in a natural reservoir that may be used in the place of artifically compressed gas. Occasionally an oil field, in which repressuring may be contemplated, is located in proximity to a transmission line that can supply gas at the pressure and in the volume desired for the initial stages of the secondary recovery operation. However, in course of time some form of compression plant will be required almost inevitably for the cycling of produced gas and for the manufacture of casinghead gasoline. Frequently, a compression plant may already be available or a vacuum plant may be converted for the purpose desired.

As the amount of increased production, in terms of actual barrels of oil per day, may be small, even though the percentage increase may be substantial, the utilization of all possible existing facilities will be favored generally. However, the same fundamental principles and considerations that will govern the selection of new equipment and its installation and operation will apply to the problems involved in the reconversion to new use of plants designed originally for other purposes. Therefore, in this chapter, primary attention will be devoted to the requirements associated with the design and construction of new compressor plants for secondary recovery operations.

As economy in the initial investment and in operating expense over the considerable period during which the repressuring program may be effective will control directly the profit that may be anticipated, the margin of which many times is small, elaborate plants, such as are found frequently in modern pressure maintenance operations, are not common in secondary recovery work. The moderate volumes and pressures generally required to produce the desired effects in the older, shallow fields are not comparable to the requirements for primary pressure control in deep, high-pressure reservoirs. If such should be the case, many presently successful gas repressuring operations would not be feasible, because of high development cost.

● **II. Preliminary tests.** The studies that should be conducted and the laboratory tests that should be made to determine the recovery of oil that can be expected from a contemplated gas repressuring operation have been considered adequately by various authorities, notably in the recent API study on "The Criteria for Determining Oil Fields' Susceptibility to Secondary Recovery Methods"[1], and by Earlougher[2]. The necessity for such investigations should be obvious and may be emphasized on account of the almost certain disaster that will result from ill-advised attempts to obtain increased oil recovery where the content of the reservoir is insufficient or where the physical properties of the reservoir are unfavorable.

Having established that conditions in a reservoir are favorable for a repressuring program, field tests, under competent engineering supervision, should be made in order to determine the number of injection wells and the pressure-volume relations that will be required. The technique that should be employed in field tests and the methods that should be used for their power interpretation have been discussed in detail by Bossler and Dickey[3], and by Cable[4], and need not be repeated herein. The information so obtained will enable the selection of compressor facilities having adequate capacity for the projected repressuring program.

Preliminary engineering studies should include, of course, a thorough investigation of the available gas supply. If the supply is found to be deficient and cannot be increased from other sources, the decision must be made whether it should be supplemented immediately by air or whether plans should be made to begin repressuring on a restricted scale and expand it subsequently as more gas may become available after a complete cycle has been established. As the writer has pointed out previously[5], the use of air for repres-

*Presented before American Petroleum Institute Southwestern District Division of Production, Shreveport, Louisiana, May 17 and 18, 1946. (Revised 1947).

[1]Offices at Houston, Texas.

suring, either alone or mixed with combustible gas, will produce various technical problems that should receive careful consideration before it may be adopted. The urgency for augmented oil production may be the controlling factor in determining whether an immediate larger increase will compensate for the inescapable operating problems that will accompany the use of air in repressuring projects.

The design of every repressuring plant should be sufficiently flexible to permit expansion or reduction in capacity or in operating pressure as changing conditions, brought about by an increase in the repressured area or by the depletion of the reservoir, may require. Therefore, generally it will be found to be more practical to install several compression units of moderate size rather than one large unit capable of supplying the entire calculated output. Whether all the compressors should be housed in one building or should be distributed about as individual units will depend, among other things, upon the geography of the field, the amount of new pipe line construction that will be required, and upon the possible future expansion of the project. In some of the intermittent type of injection systems, which have gained considerable popularity in certain of the eastern fields, the use of small, semi-automatic units, that require only periodic attention, has proved to be very practical. Elsewhere, and especially in unitized fields, integrated operations may result in economies that cannot be overlooked. No fixed rule that might be applied to all conditions may be offered, and the foregoing discussion is presented principally to focus attention to the need for competent engineering supervision in the formulation of plans for each particular project.

● **III. The design of compressor plants.** *(1) The compression of gas.* The gas repressuring of older fields as a means for increasing oil recovery involves the compression of the injection medium and its subsequent introduction into the reservoir by means of intake wells. Practically all compressors employed for this work are of the reciprocating type that may be operated by direct connection to the source of power by a connecting rod or by a belt drive. The compressor will consist of one or more cylinders containing close-fitting pistons and valves so arranged and operated to permit the intake of low pressure gas and the escape of high pressure gas into and from the compression cylinder. Most modern compressors are double acting; that is, gas is taken into the cylinder at the crank end while it is being discharged from the head end on the up stroke of the piston and vice versa on the return stroke. However, on some of the smaller projects, single acting compressors are still in use.

In actual practice the compression of gas always involves some change in temperature and there is always some loss of heat due to radiation from the cylinders and to water or oil cooling. Thus, the process of compression is not truly isothermal; neither is it truly adiabatic, but rather it is in an intermediate stage known as polytropic and may be expressed in accordance with the following formula:

$$P_1V_1^n = P_2V_2^n = C \quad . \quad . \quad . \quad . \quad (1)$$

Where:

P = absolute pressure of the gas in lb. per sq. in.,
V = volume of the gas in any convenient units,
n = the exponent of compression, and
C = a constant.

The exponent of compression "n" may be determined from an indicator diagram and according to Gill[6] is dependent upon the characteristics of the gas compressed, the degree of cooling, the condition and design of the compressor valves, and to the condition of the rings in the compression cylinder. Operating experience has indicated that an approximate value of 1.2 for "n" is fairly close to actual conditions in the average compressor, but may vary depending on whether dry or wet natural gas or air-gas mixtures of varying proportions are used.

(2) Power requirements of compressors and fuel control. With the value of "n" either determined or assumed, the horsepower required for the compression of a given quantity of gas in a given length of time can be determined. For all practical purposes, the power required for compression is of less importance and should not be confused with the somewhat larger brake horsepower that the prime mover must deliver to the compressor both to compress the gas and to overcome the friction in the moving parts of the compressor. According to Gill[6], the brake horsepower can be calculated by the use of the following formula:

$$\text{B.hp. per MM. cu. ft.} = \left[\frac{44.5\,n}{n-1}\left(R^{(n-1)/n} - 1\right) + 10\right]\left[1 + \frac{R^2}{350}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Where:

B.hp. per MM. cu. ft. = b.hp. of compression per million standard cu. ft. of gas at 14.7 lb. per sq. in. and 60°F. per 24 hr.,
n = exponent of compression
R = pressure ratio $\frac{P_2}{P_1}$
P_2 = discharge pressure in lb. per sq. in., abs., and
P_1 = intake pressure in lb. per sq. in., abs.

In equation (2) the constant "10" is regarded as being applicable for compressors up to a range of 200 to 300 hp, generally about the maximum size used in secondary recovery work.

The supply of fuel gas for compressor engines must be regulated precisely and the apparatus for this purpose should be of simple construction and should not require frequent repairs or adjustments. The last regulator should be sufficiently sensitive to maintain the pressure with a variation of less than 1 per cent. For installations where more than one four-cycle compressor unit are required, a common fuel header, of sufficient size that there will be a pressure drop of only from 3 to 5 in. of water for the entire length, has proved to be quite satisfactory. Where the use of air-gas mixtures for fuel can be anticipated, adequate provision should be made for increased intake of fuel in relation to air.

Ignition of the gas in the compressor engine has usually been by means of magnetos or by direct-current impulses from storage batteries. Quite recently individual direct-current rectifiers of the copper oxide type have been developed as a substitute for the forms of ignition equipment just cited. These units utilize electric energy from a 440-volt, 3-phase, 60-cycle source, and with an integral transformer, they supply steady and uniform direct current for the ignition system of all engines.

(3) Displacement and capacity of compressors. The volumetric displacement of a compressor is the volume of gas, measured at intake conditions of temperature and pressure, that the compressor will handle for any given time period. For a single acting compressor it may be determined by the following equation:

$$D_n = 0.000454d^2LN \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Where:

D_n = nominal displacement in cu. ft. per min.;
d = bore of compressor cylinder, in.;
L = length of piston stroke, in., and
N = speed of compressor, rpm.

If the nominal displacement in M. cu. ft. per 24 hr. is desired, equation (3) can be changed as follows:

$$D_n = \frac{0.000454\ d^2\ LN \times 60 \times 24}{1000}. \quad (4)$$

For double-acting compressors, a correction in either equation (3) or equation (4) must be made for the reduced capacity on the reversed stroke because of the volume of the piston rod extending through the cylinder. Ordinarily, these corrections may be obtained from tabulations supplied by compressor manufacturers, but should these not be available the factors may be determined by actual measurement of the bore of the cylinder, the length of piston stroke, the dimensions of the piston, and the diameter and length of the piston rod.

(4) Efficiency of compressors. The volumetric efficiency of a compressor is the ratio of the volume of gas actually handled under the conditions of pressure and temperature prevailing at the intake to the volume discharged by the compressor piston in a given time period. It is a function of the clearance ratio, which is the ratio of the clearance volume to the displacement volume, the ratio of absolute discharge pressure to absolute intake pressure, and the exponent of compression, as defined in Title III-1 herein. As stated by Gill[6]:

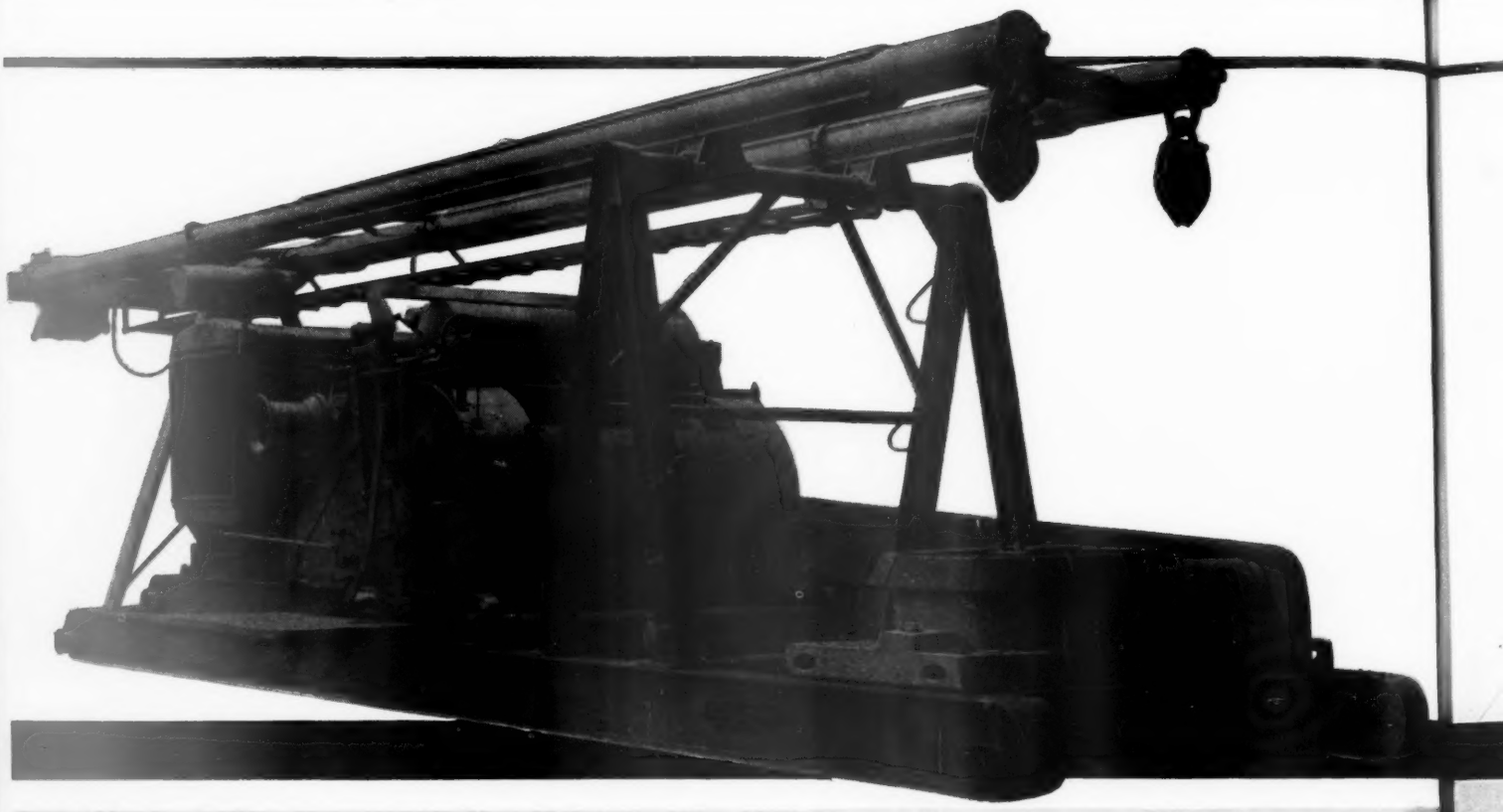
$$E_v = 0.98 - c(R^{1/n} - 1) \quad . \quad . \quad . \quad . \quad (5)$$

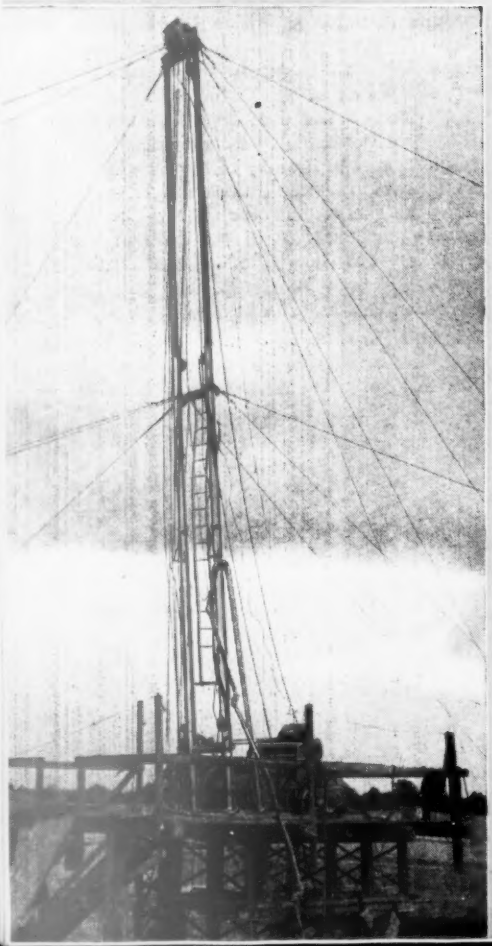
Where:

E_v = volumetric efficiency,
c = clearance ratio (clearance is the volume of space in the compressor cylinder enclosed between

UNIVERSITY OF MICHIGAN LIBRARIES

For Profitable
WELL SERVICING U





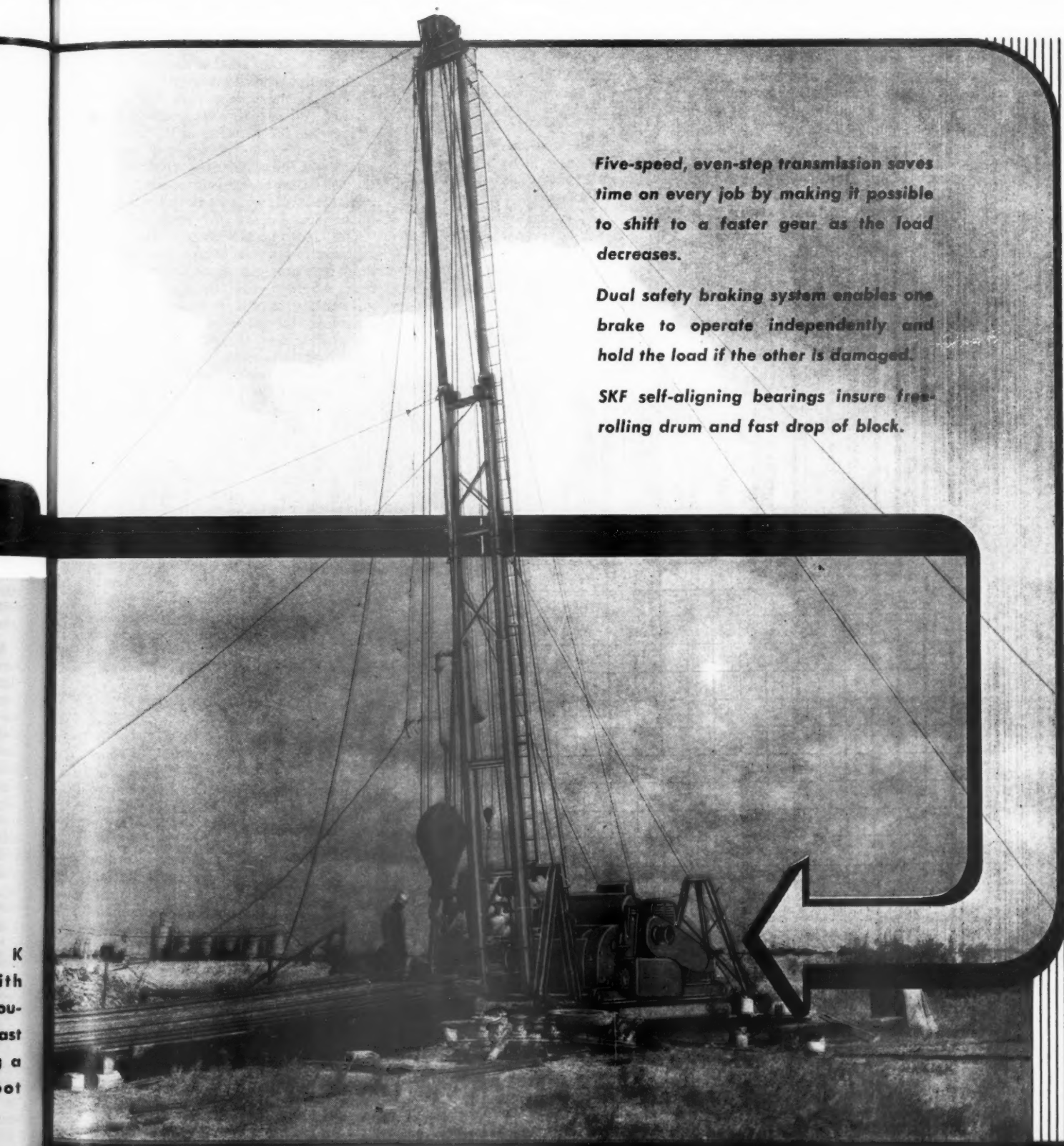
The "Cardwell" Model S hoist shown above is equipped with rotary table drive assembly, and is mounted on subframe with rotary table and 55- or 65-foot double leg mast.

This complete rig is recommended for rotary workover jobs using tubing or lightweight drill pipe.

Three smaller sizes, Models Q, H and K, are available for well servicing from 2,000 to 6,500 feet. All hoists are available with single or double leg masts, and Models H, K and S with rotary drive assembly.

Model K hoist with 55-foot double leg mast swabbing a 4,869-foot well.

G USE A "CARDWELL"



Five-speed, even-step transmission saves time on every job by making it possible to shift to a faster gear as the load decreases.

Dual safety braking system enables one brake to operate independently and hold the load if the other is damaged.

SKF self-aligning bearings insure free-rolling drum and fast drop of block.

CARDWELL ALL STEEL
REG. U.S. TRADE MARK PAT. OFFICE
THIS TRADE MARK INSURES HIGHEST QUALITY AT LOWEST PRICE

CARDWELL MFG. CO. INC.

P. O. Drawer 2001 . . Long Distance Telephones 128 – 129 – 130
Cable Address: "ALL STEEL," Wichita — "CARDSTEEL," New York
Wichita, Kansas, U. S. A.

"CARDWELL" RIGS ARE STRONGER, WEAR LONGER AND WEIGH LESS

UNIVERSITY OF MICHIGAN LIBRARIES

the cylinder wall, piston face and valves when the piston is at the end of the stroke for the given end of the cylinder),

R = ratio of absolute discharge pressure to absolute intake pressure, and

n = exponent of compression.

(5) Effect of supercompressibility of natural gas on compressor performance. When conditions of pressure and temperature prevail that cause the gas that is to be compressed to deviate from the ideal gas laws, consideration must be given to the supercompressibility factor in order to predict accurately the volume throughput and the horsepower requirements for the plant. The effect of supercompressibility is more prominent at high pressures, but even in low pressure operations, if gas carrying an appreciable hydrocarbon content heavier than methane is being handled, there may be a very considerable deviation. Consequently, unless the effect of the supercompressibility factor is understood, it may be discovered, after compressors have been installed, that the throughput volume and the horsepower requirements are much larger than that calculated.

The effect of supercompressibility of natural gas upon compressor performance has been treated very adequately by Ridgeway[7] who has developed the following formulae for the determination of cylinder capacity:

$$\text{Cylinder capacity} = \text{cylinder capacity calculated neglecting supercompressibility} \times \frac{E_{vs}}{E_v \times Z_s} \quad . \quad . \quad . \quad . \quad (6)$$

$$= \text{cylinder displacement} \times \frac{E_{vs} \times \text{suction lb. per sq. in. abs.} \times 520^\circ}{Z_s \times 14.7 \times (460 + t^\circ \text{ suction})} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Where:

E_{vs} = volumetric efficiency,

E_v = volumetric efficiency, and

Z_s = supercompressibility at suction pressure and temperature.

If the brake horsepower disregarding the supercompressibility factor has been determined for a unit volume of the gas to be handled, the brake horsepower requirements recognizing supercompressibility can be ascertained by multiplying the theoretical brake horsepower by the average of the suction and discharge supercompressibility factors. However, as discussed in detail by Ridgeway[7], since the effect of supercompressibility is to increase the capacity of the compressor cylinder, the horsepower requirement will increase proportionately as the actual expanded volume bears to the expanded volume calculated according to the ideal gas laws.

(6) One and two stage compression. If the ratio between intake pressure and discharge pressure is much greater than from 4.5 to 5, the temperature of the gas becomes very high, which may effect harmfully the oil used to lubricate the compressor and, thereby, may result in damage to the cylinder walls and the valves. By the use of two-stage compression, with the gas passing through intercoolers between stages, an overall pressure ratio of up to 25 may be obtained without excessive temperatures developing in either cylinder.

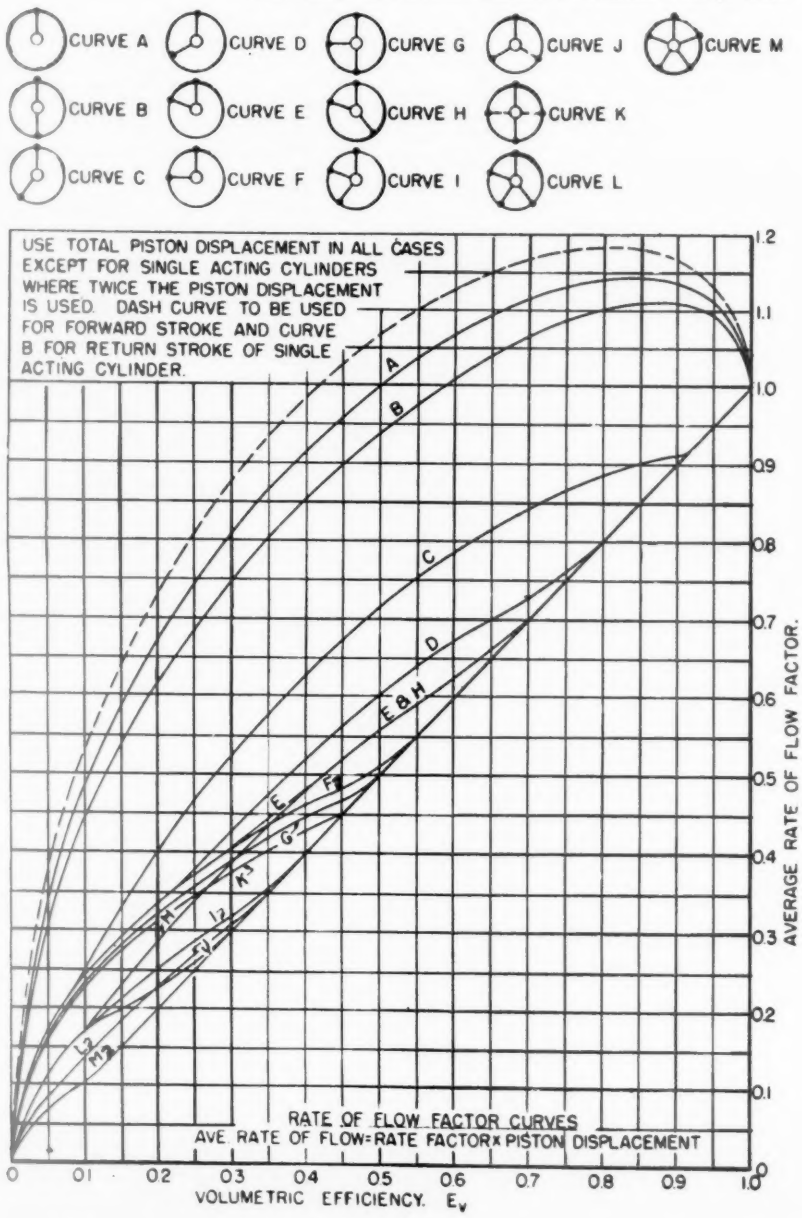
If the need for two-stage compression is obvious, the work of compression should be divided as equally as possible between the two stages.

(7) Pipe connections for compressor installations. The flow of gas from a compressor cylinder varies from zero to a maximum with each complete revolution. Gas is taken into the cylinder during part of one stroke and is discharged during part of the next stroke, the exact amount taken in and pushed out being dependent upon the volumetric efficiency of the compressor cylinder. The rate at which the gas is taken in and discharged depends, of course, on the speed of the piston. Therefore, since the gas is not going in or leaving the compressor at a constant rate the average rate of delivery of gas should not be used to determine the most efficient size for suction and discharge lines. An assumption of constant gas flow from the compressor will result in the selection of too small sizes of pipe that, in turn, will be responsible for the development of a greater drop in pressure between the compressor and the header than would take place by the use of pipe of larger diameter. The pressure drop, brought about by undersized piping, frequently may be the reason why an otherwise correctly designed compressor plant will not deliver its rated capacity or to do so must operate under an overload.

If a compressor plant has more than one unit, the headers connecting the compressors should be large enough to take care of the gas flowing to or from the compressor cylinders when all of the units are synchronized. If too small

FIG. 1. Rate of flow factor curves.

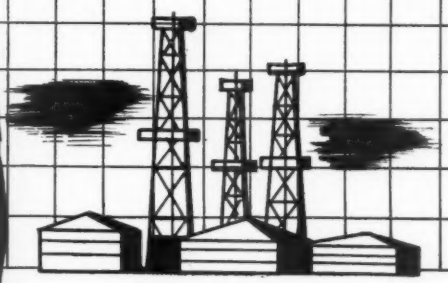
From "Calculating Pipe Sizes for Compressor Cylinder," by B. C. Thiel, The Petroleum Engineer, November 1943, p. 135.


CURVE A
CURVE D
CURVE G
CURVE J
CURVE M
CURVE B
CURVE E
CURVE H
CURVE K
CURVE C
CURVE F
CURVE I
CURVE L
USE TOTAL PISTON DISPLACEMENT IN ALL CASES EXCEPT FOR SINGLE ACTING CYLINDERS WHERE TWICE THE PISTON DISPLACEMENT IS USED. DASH CURVE TO BE USED FOR FORWARD STROKE AND CURVE B FOR RETURN STROKE OF SINGLE ACTING CYLINDER.
AVERAGE RATE OF FLOW FACTOR.
RATE OF FLOW FACTOR CURVES
AVE. RATE OF FLOW = RATE FACTOR x PISTON DISPLACEMENT
VOLUMETRIC EFFICIENCY, E_v

When Tret-o-lite goes in...

Treating Costs

Go Down



TRETOLITE COMPANY

Manufacturing Chemists

St. Louis 19, Missouri — Los Angeles 22, California

DEHYDRATING DESALTING

TODAY the economy of Tret-O-Lite demulsification compounds is recognized by oil producers everywhere. Years of application to crude oil emulsion problems under all producing conditions have resulted in the development of effective fast-performing formulas that deliver maximum savings in money, time and production. Call your Tretolite field engineer... his laboratory background and years of practical experience should prove profitable to you.

Complete Service for Every Field

headers are installed the capacity of the station will be decreased and the horsepower required to compress a unit of gas will be increased. Losses in horsepower have been reported amounting to as much as 35 per cent of the productive horsepower in plants having undersized piping or any restrictions in the headers or intercoolers.

Methods for the determination of the average momentary flow rate for the cylinder during the suction or discharge stroke have been developed by Thiel[8] and may be used to calculate the most efficient size of intake and discharge pipe fittings. In discussing a rate factor curve, Fig. 1, which eliminates much of the burdensome graphical analysis of calculation, Thiel states: "This curve, (Fig. 1), is based on a double acting compressor cylinder having a crank rod ratio of 1 to 5. This ratio was chosen because it is closer to the present-day American practice. Using this curve requires that only the volumetric efficiency and the piston displacement of the cylinder be known. The rate factor, corresponding to the volumetric efficiency is found and multiplied by the piston displacement giving the average rate of flow in cu. ft. per min. For single-acting compressors the rate factor must be multiplied by twice the piston displacement to arrive at the correct average rate of flow."

It is contended by some engineers that correct sizes for suction and discharge lines can better be determined by actual measurements in surge chambers which serve to eliminate or diminish the amplitude of the pulsating flow. Under some conditions, it is believed that this method will provide a better approximation of flow velocities.

When two or more cylinders take suction from or discharge into the same pipe line the average rate of flow for this group of cylinders is not the summation of each of their average rates of flow. In this case the solution can be either graphical or algebraic. The graphical solution is better because it shows the maximum and minimum rates of flow during the time gas is flowing to or from the compressor cylinder.

Where high pressures must be carried on the system, a design of pipe connections to and from the compressor units to conform to Section 3, Division 2 of the Code for Pressure Piping by the American Standards Association, designated as ASA-B 31.1-1942, is favored. This is the same code employed for oil and gas pipes within the operating limits of refineries and conformance to it provides an additional safety factor to the concentration of employes and valuable equipment in the relatively restricted area of the compressor plant.

For the greatest operating efficiency, the intake pipe to the compressor should be as short and direct as possible. The use of long radius elbows is favored wherever bends may be necessary. The size of the intake pipe should be equivalent to the full diameter of the intake opening of the compressor cylinder, and if the intake pipe is longer than 12 ft., the next larger size should be employed.

Discharge pipes should not be smaller than the full size of the discharge opening from the compressor cylinder and should run directly to an aftercooler, if one is used, and should be equipped with suitable traps and drain valves for the removal of any liquid that may accumulate. Straight discharge pipes are preferable and if any bends are necessary long radius elbows should be used. As discharge pipes are invariably hot, protective insulation against burns is desirable.

All connections to the discharge cylinder should be flanged so that the cylinder can be removed without disturbing the pipe system, and all discharge pipes should be so anchored or supported to reduce vibration, resulting from the pulsating discharge of the compressor, to a minimum.

Control of pipe vibration has been one of the most difficult problems connected with the design of compressor plants. The use of exceptionally rigid pipe may reduce vibration to a minimum as well as heavy clamps or anchors at the points where the most noticeable vibration takes place. The adoption of a form of exhaust silencer to break down the most prominent pulsating effects is a promising, fairly new method to combat the problem of vibration, where clamps and anchors will not permit normal contraction and expansion of the pipe, which will result from changes in temperature.

(8) The cooling system. According to Thiel[9], an inadequate or unsuitable cooling system for the cooling of internal-combustion engines and gas compressor cylinders has increased the maintenance cost of compressor stations substantially. Plans, therefore, for an effective cooling system are of great importance.

If the compressor plant should be situated adjacent to a continuous and plentiful source of chemically satisfactory water supply, little concern need be given to the cooling system for it may be assumed that the internal system supplied by the manufacturer will be satisfactory. In arid or semi-arid regions where the source of supply is not adequate to permit the wasting of the cooling water, a cooling pond or a tower must be constructed in order to permit the reuse of the water. Such an installation will permit a better temperature control of the cooling system, it being obvious that the differential between winter and summer outdoor temperatures in most parts of the United States will result in expansion and contraction strains within the compressor cylinder that will result in excessive liner and piston wear. On this account, a closed cooling system that is charged with clean, pure water, which permits careful control of temperature differential and the formation of scale, under conditions of limited water supply is most desirable. Where conditions permit, condensed steam can be used advantageously for this purpose.

Various types of cooling systems have been described by Thiel[9]. He emphasizes that careful consideration should be given in the selection of pumps for the cooling system and particular attention should be given to the effect of small changes in head on the capacity of centrifugal pumps. It is recommended that a preliminary plan of the water cooling system should be developed that will show the length of the system and all fittings and connections, and the probable pressure drop through heat exchangers, cooling coils, and engine and compressor jackets. By adding the various pressure losses the total pressure loss may be determined, and knowing the quantity of water to be circulated a tentative selection of pump capacity can be made. All such determinations and a complete plan of the entire cooling system should be submitted to the compressor manufacturer and checked by him before an order is made for new equipment.

As stated by Thiel[11], "In an open cooling water system where the water is cooled by means of a cooling tower, the daily make-up of water is never less than 5 per cent, which causes an accumulation of sludge in the cooling water tower basin great enough to necessitate the draining of the system and cleaning of the tower basin every few months if the formation of scale in the engine jackets and cylinder heads is to be held to a minimum. Then, too, the faculty of water in an open system of absorbing oxygen from the air makes the oxygen loaded water highly corrosive when it is heated and the oxygen released in the engine jackets and heads. This is particularly true in water-cooled piston rods as the oxygen will attack steel with greater avidity than cast iron. In a closed system, the amount of makeup water is almost negligible provided the system is free from leaks.

The most reliable closed system is one where the pump draws the water from the overflow tank or standpipe and forces the water through the heat exchanger and the engine to the overflow in the overflow tank or standpipe. The overflow tank or standpipe should have its cover vented to the atmosphere and be so constructed that the water surface exposed to the air is a minimum. The overflow line from the engine should enter the standpipe a short distance below the normal level of the water in the standpipe so as to prevent any splashing, as this would increase the amount of air dissolved in the water, but this should be high enough to provide for a continuous slope upward from the engine to the standpipe. This will release any entrained air or gas in the cooling water stream, in fact, all piping should have an upward slope from the time it leaves the pump discharge until it enters the standpipe.

If, due to necessities of design, the water piping must deviate from a continually rising line at any point, an automatic air vent or a small bleeder line should be installed at the high point in this line.

All water piping should be calculated for water velocities not exceeding 4 ft.

TWO BEST WAYS TO SOLVE YOUR EMULSION TREATING PROBLEMS!

By incorporating features never before employed in breaking down oil and water emulsions, Parkersburg Self-Insulating Emulsion Treaters and Parkersburg Horizontal Direct Heaters have established a new standard of efficiency in fields everywhere.

Parkersburg Treaters, for example, have twice as much settling space as some similar types of treaters. They are self-insulating. In addition, pre-heating of emulsions and even heat distribution adds materially to their efficiency.

Parkersburg Heaters combine radiation and convection heat in an unique manner that minimizes scale deposits . . . maintains greater efficiency. Ask your Parkersburg Representative for details. You can't buy better equipment to solve your emulsion problems.

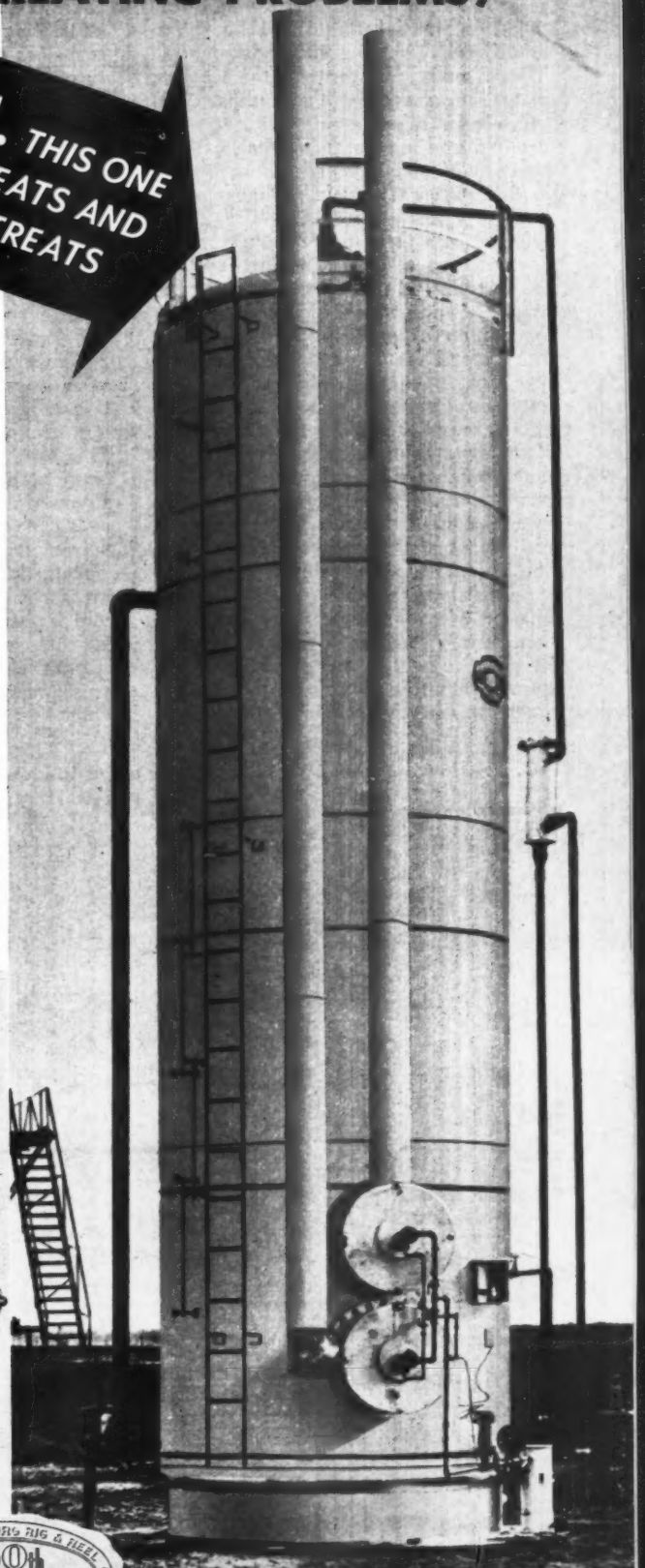
THE PARKERSBURG RIG & REEL CO.

PARKERSBURG & OCS PRODUCTS

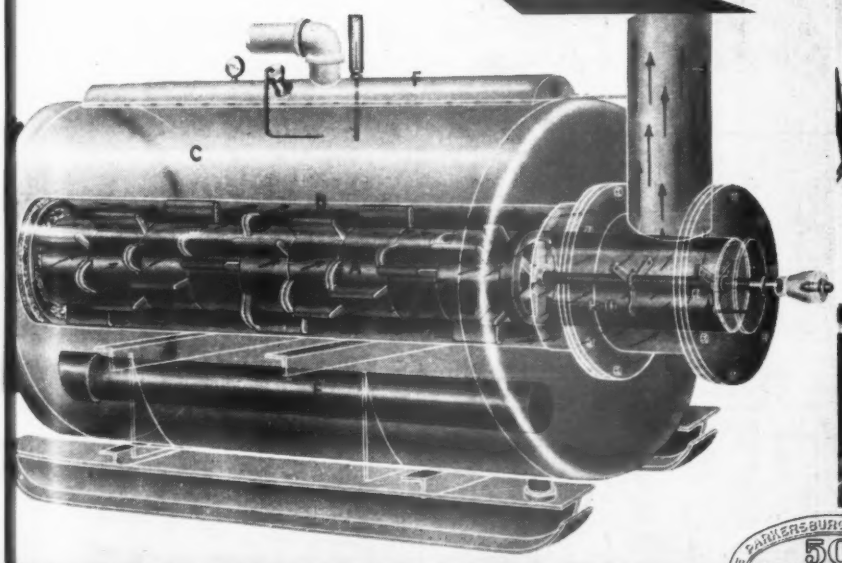
GENERAL OFFICES, PARKERSBURG, W. VA.
Plants at Parkersburg, W. Va., Coffeyville, Kan., Houston, Texas
District Offices:
Dallas - Houston - Los Angeles - Tulsa - New York

OCS

1. THIS ONE HEATS AND TREATS



2. THIS ONE HEATS



THE PARKERSBURG RIG & REEL CO. 50th ANNIVERSARY 1897-1947 PARKERSBURG, W. VA.

PARKERSBURG

per sec. and in case this velocity creates too great pressure drop due to long pipe lines, the pipe size should be increased. The quantity of water necessary to cool an installation containing 1000 b.hp. in main units is 525 gal. per min. for a 20°F. differential, 700 for a 15°F. differential, and 1050 for 10°F. differential. These quantities contain the cooling water necessary for the auxiliary engines and other auxiliaries requiring cooling, and are based on the heat dissipation of an oil-cooled piston 2-cycle engine with water-cooled exhaust manifold.

There are three general methods of constructing a closed cooling system. One is to install tubes through which the treated cooling water is led near the bottom of an evaporating cooling tower. The second is to use a shell-and-tube type heat exchanger, flowing the raw water through the tubes and the treated water around them. The third is the radiator type that has proved to be advantageous in small plants situated in arid regions. The selection of whichever system is used depends upon the general layout of the station and its situation in regard to the water supply.

As the power requirements for the circulation of cooling water are considerable, any system that does not provide for effective heat exchange with a minimum of pumping may prove to be quite expensive. In the modern compressor plant water cooling is required for compressor engine jackets, electric generator engine jackets, compressor cylinders, lubricating oil coolers, and for intercoolers and aftercoolers of the compressed gas. The use of a common source of cooling water in one continuous system does not permit desirable temperature and quality control, so as a substitute a two-circuit system has been developed by Dawe[10] that provides low power cost, close temperature control, and which may be modified to meet requirements of warm and cold climates. Two separate systems are used. One, the hot system, circulates water through the compressor cylinder jacket and generator jackets in parallel. The proper volume of cooling water is carried 140°F. and has a maximum rise of 10°F. Fig. 2 shows diagrammatically the flow in such a system using atmospheric sections. Fig. 3 shows a similar system making use of shell-and-tube exchangers. This type of hot system may have the temperature controlled by installing an automatic control to bypass the cooling coils. The temperature rise is small and the quantity of water circulated and in makeup is at a minimum so water quality is easily controlled. The second, or cold system, circulates water through the compressor and generator oil coolers in parallel and finally through the compressor cylinder jackets, the excess water flow being bypassed. This volume of water is such that the temperature may be controlled by use of an automatically controlled bypass valve, and the closed system allows for close quality control with little makeup water. This system operates at a temperature of about 110°F. inlet and about 120°F. outlet.

The use of the two separate systems allows segregation of cooling coils in the cooling tower and better distribution of cooling water.

(9) Quality of cooling water and water treatment. The water supply recommended for efficient compressor performance should have the following properties:

Dissolved oxygen — preferably zero, but not more than 0.05 cc. per liter.

pH value — not less than 8.

Oil—none.

Suspended solids—none.

Hardness—$CaSO_4$ and $MgSO_4$ added. not more than 15 p.p.m. $CaCO_3$ and $MgCO_3$ added not more than 75 p.p.m.

Organic matter — not more than 5 p.p.m.

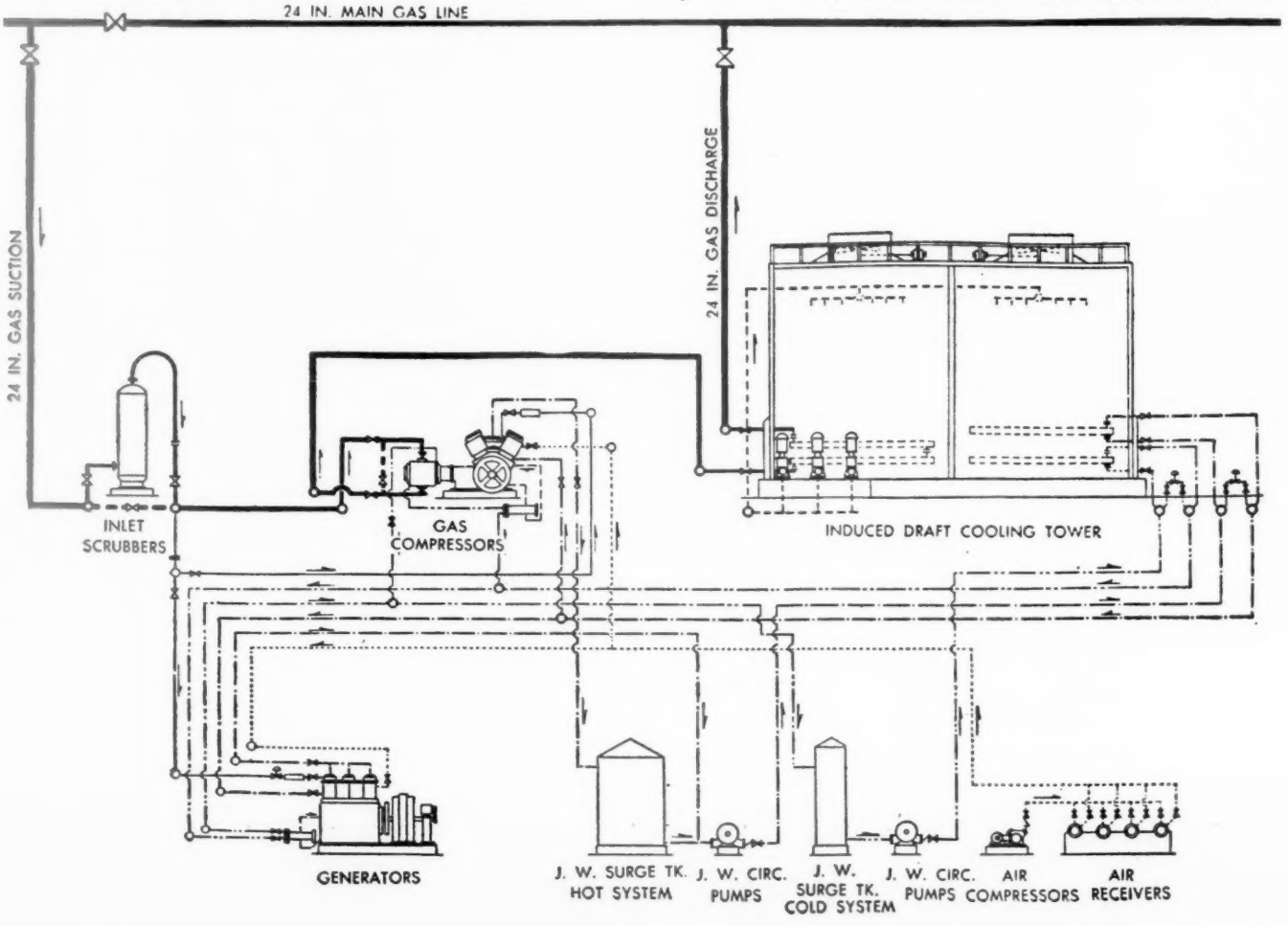
Chloride—not more than 6 p.p.m. in terms of chlorine.

All makeup water should be of the same analysis.

The complexities and necessary differences in water treatment over the entire country are so great that a multitude of processes have been developed for adaptation to varying local conditions.

FIG. 2. Flow diagram of cooling system using induced draft tower.

From "Modern Compressor Station Design," by Harold F. Dawe, The Petroleum Engineer, April 1945, p. 72.



When You Need MUD LOOK FOR THIS SIGN

Just Around the Corner

No matter where your location may be in the Gulf Coast, Mid-Continent, West Texas or Rocky Mountain areas, there's a MAGCOBAR Dealer *just around the corner!* Ample stocks of weight material, gel, clays and chemicals in 160 dealer warehouses, conveniently located with respect to oil activity, assure prompt handling of your mud requirements.

The MAGCOBAR staff of mud engineers will gladly assist you with your mud problems.

MAGNET COVE BARIUM CORPORATION

MALVERN, ARKANSAS — **HOUSTON, TEXAS**

Magcobar Magcogel High Yield Drilling Mud Xact Clay Magco-Fiber Magco-Mica
Tannathin Salt-Gel Noheev Seal Flakes My-Lo-Jel Chemicals

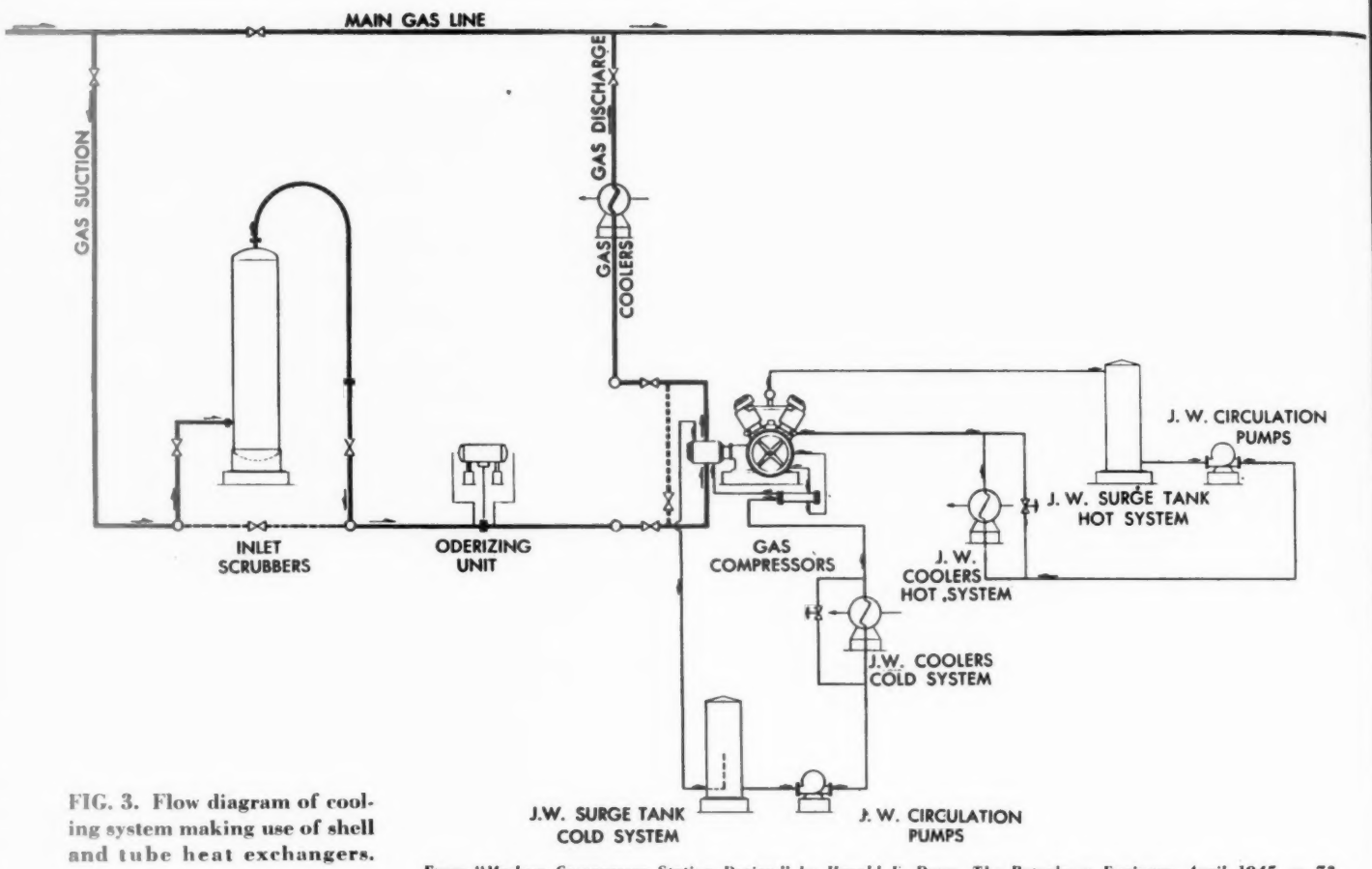


FIG. 3. Flow diagram of cooling system making use of shell and tube heat exchangers.

From "Modern Compressor Station Design," by Harold F. Dawe, The Petroleum Engineer, April 1945, p. 73.

These have been considered in adequate detail by Sanders[12] and by Hammerschmidt [13] and are summarized herein.

The heat generated by internal-combustion engines and by compressor cylinders must be carried through the cylinder walls and connecting rod surfaces to the cooling medium. Likewise, intercoolers and aftercoolers must transmit heat through treating surfaces to prevent overheating and the troubles resulting therefrom. Any insulating material produced by the deposition of scale or by corrosion defeats the purpose of the cooling system and will be the source of continued trouble unless eliminated. A scale of 0.020 in. thickness may reduce the transfer of engine heat by 10 per cent; 0.125 in. by as much as 30 per cent; and 0.250 in. by 40 per cent. The treatment of water to prevent the deposition of scale and to control corrosion, therefore, is of paramount importance.

Corrosion and the deposition of scale can be separated into two general classifications. The first includes the problems resulting from corrosion by gases such as oxygen, carbon dioxide, and hydrogen sulphide; from flinty dirt, and from bacteria and algae. The second includes the formation of scale from the deposition of insoluble carbonates, sulphates, and silica.

Corrosion from the gases can be a very serious problem and is combated by various methods. Potassium or sodium dichromate have been used for protection against oxygen, but because of recurring contamination, large quantities of these chemicals are required. As a substitute and because of their value for other forms of corrosion control, the use of inhibitors is receiving increasing attention. A variety of materials have been used for this purpose, among which are calcium and sodium hydroxide, sodium carbonate, silicate, and phosphate, tannin, and organic glucoside derivatives that are known as glucosates. The glucosate treatment has proved to be effective under some conditions, since very thin protective films, having a permanent nature, are formed. In addition, they are reported to afford positive prevention of siliceous depositions. Other forms of treatment result in objectionable products or are more expensive. Dust can be removed by effective cleaners as hereinafter described, and the growth of microorganisms can be controlled by treating the water with chlorine or copper sulphate. A combined treatment of ammonia and chlorine is being favored as a means for prolonging germicidal efficiency of the treatment.

The most simple method for the removal of calcium and magnesium compounds from the cooling water is the zeolite process, which substitutes sodium for the objectionable positive radicals. Also used extensively is the lime-soda process, which changes the soluble calcium and magnesium bicarbonates to insoluble compounds that are precipitated and can then be filtered out.

In some very hard waters, pretreatment of the water by the zeolite or lime-soda process and then subsequent treatment to maintain finely divided insoluble material in colloidal suspension, may be required. It is reported that beta glucoside and certain of its derivatives have been used effectively for secondary internal treatment.

(10) Cooling towers and heat exchangers. Mention has been made previously of the desirability of automatic volumetric control of the cooling water, of proper water velocity, and of the volumetric requirements to produce certain heat differentials. The figures that have been presented include the water necessary for average auxiliary cooling purposes.

Cooling towers should be designed to remove as much heat from the water as can be extracted per unit of space occupied by the structure. The water is sprayed from the top of the tower and is maintained in a finely dispersed condition by counter currents of saturated air maintained in open systems by natural draught and in closed systems by forced draught with a fan. The water coming from the spray jets usually falls on a distribution deck, which keeps it separated into fine streams and carries it through troughs to the series of descending baffles that finally carry it to the accumulating pond or tank.

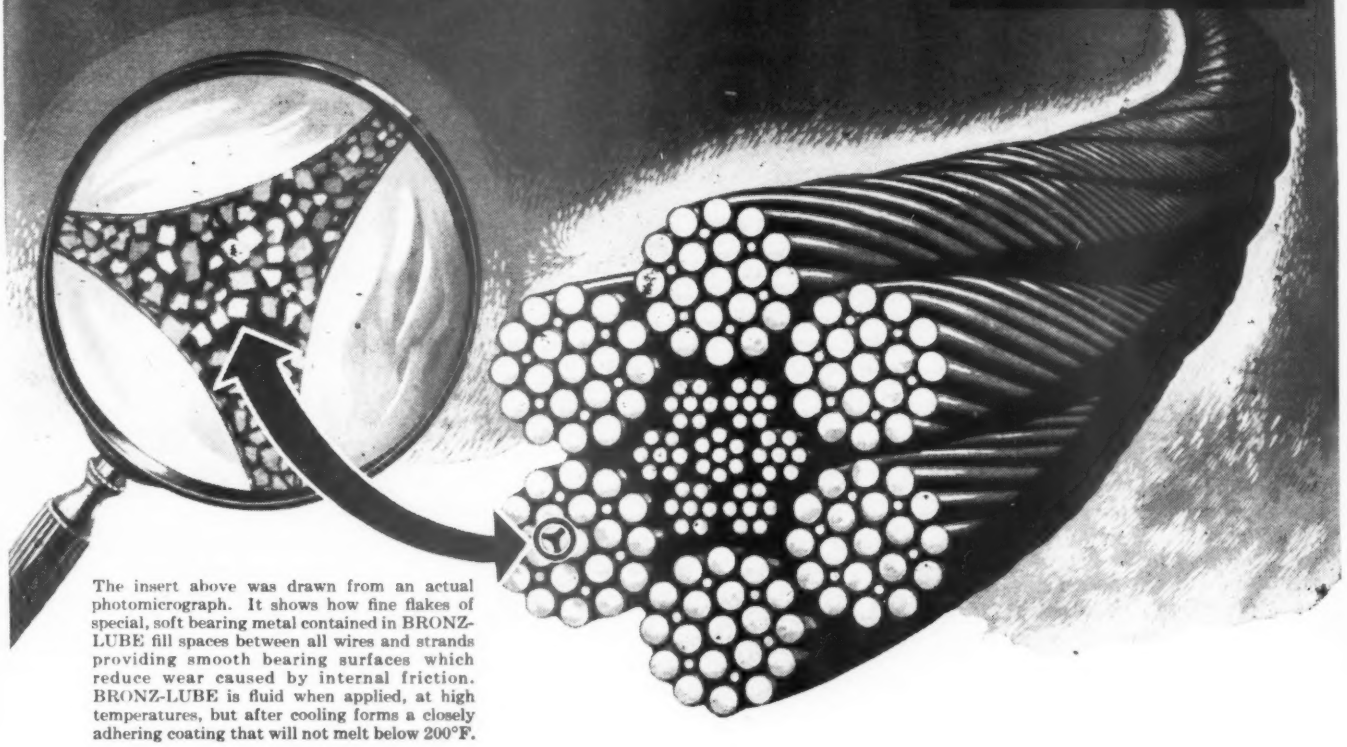
As is well known, cooling towers are chiefly constructed from some decay resistant wood such as cypress or redwood on a steel framework. The use of alkaline chemicals in water treatment has a detrimental effect on the structure

For Longer Service Life

ALL J&L PERMASET PREFORMED WIRE ROPE

Now Lubricated with **BRONZ-LUBE...**

J&L STEEL



The insert above was drawn from an actual photomicrograph. It shows how fine flakes of special, soft bearing metal contained in BRONZ-LUBE fill spaces between all wires and strands providing smooth bearing surfaces which reduce wear caused by internal friction. BRONZ-LUBE is fluid when applied, at high temperatures, but after cooling forms a closely adhering coating that will not melt below 200°F.

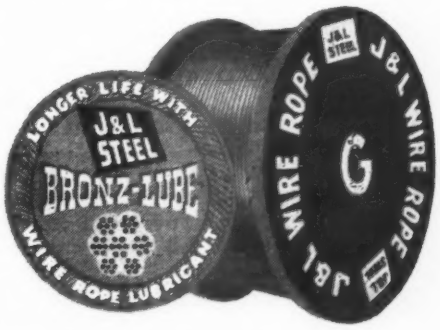
. . . Containing soft alloy bearing metal that plates each wire and strand for longer wear!

Wire ropes are machines and like all machines need the best lubricant to give long service life. BRONZ-LUBE a new exclusive J&L wire rope lubricant, contains minute particles of soft anti-friction bearing metal. This new expensive lubricant with exceptional qualities for adhering to steel has been developed through months of research by J&L wire rope engineers and lubrication experts. Each individual wire, each strand and the entire J&L wire rope is coated with this superior, longer lasting lubricant. It reduces wear caused by internal friction when the rope is working under heavy loads and flexing over sheaves and drums. BRONZ-LUBE having a high film strength of 50,000 lbs. per square inch will not "squeeze out" between rope wires under extreme lateral pressures.

In addition to being a better lubricant, BRONZ-LUBE is water repellent —retards washing off even in salt water. BRONZ-LUBE prevents corrosion . . . resists abrasion. The perfect bond between BRONZ-LUBE and steel wire provides a plating composed of petroleum and soft bearing metal that does not creep, wipe off, or drip, even on a hot summer day. Yet it is extremely flexible and does not harden, crack or decrease in adhesion at 40° below zero! You get all these advantages at *no extra cost* when you buy J&L Wire Rope lubricated and protected with BRONZ-LUBE.

All J&L permaset preformed wire rope is lubricated with BRONZ-LUBE. It is already setting new performance records in earth moving, material handling and oil well drilling. You can obtain this longer service . . . reduce your maintenance costs with J&L BRONZ-LUBE protected Wire Rope. Place your order now with your J&L wire rope distributor or any J&L sales office or warehouse.

Keep exact wire rope performance data. For free wire rope service record cards and convenient plastic holder, write on business letterhead to Wire Rope Sales Dept., Room 918 Jones & Laughlin Building, Pittsburgh 30, Pa.



JONES & LAUGHLIN STEEL CORPORATION

of the wood, producing what is known as delignification. The combination of the sodium ion with the lignins, tannins, and cellulose ingredients of the wood renders it so porous that it will not hold nails or other attached hardware. The lumber will actually take on the appearance of premature rotting.

The control of the process of delignification of wood is a most important problem where alkaline compounds are required for water treatment. No positive method for the complete elimination of this process is known, but there are means for minimizing its effects. Impregnating all wood work with oil has been used in some installations, but this form of treatment produces fire hazards and also makes possible the contamination of the water with oil. Another method that has been used recently to retard delignification is to treat the lumber, after fabrication, with water repellent chemicals and thus prevent the cooling water from penetrating the grain structure of the wood. Coating the woodwork with aluminium or asphaltic paint is a temporary protective measure, which has to be repeated about every year with resultant shut down of the plant.

Various authorities are emphasizing the use of fans and radiating types of coolers for both oil and jacket water.

(11) Air and gas filters. The removal of dust, dirt, and pipe scale from the air and gas used in the engines driving compressor cylinders and from the gas to be compressed may be necessary to prevent excessive abrasion of cylinder walls and ends. This is particularly true in parts of the Mid-Continent and Southwestern areas where dust storms prevail.

If it is determined that filtration of air is desirable, care should be exercised that the equipment installed is of sufficient size that minimum pressure drop is created between the atmosphere and the engine cylinder. This is particularly essential for two-cycle engines whose power output is quite sensitive to a slight pressure drop. However, for both two-cycle and four-cycle engines, any restriction in the free air intake to the combustion cylinder will tend to enrich the combustible mixture and may cause the engine to run hot.

The removal of dust from gas to be compressed and to be used for fuel can be accomplished in various ways. The most common method is to mix the gas intimately with some liquid so that the dust particles will be moistened, and then run it through a scrubber to remove any liquid, carried along as a fine cloud suspension, in addition to the moistened particles. A light oil is usually used in the scrubber, which can be filtered as it becomes dirty and then reused.

The use of electronic dust precipitators has been suggested, and it is believed that these devices will enable a quite thorough dust removal by a much less complicated process than the one that is in general use at the present time.

(12) Oil coolers and filters. Since the pistons in power cylinders of many modern compressors are cooled by circulating oil rather than by water, the proper after-cooling of the oil before it is recirculated is essential. Such coolers should not create a high-pressure differential and should have high heat exchange capacity. The cooling water used for this purpose should be circulated separately from the water used for intercoolers and for the cooling of the compressor cylinders, for the compressor may operate at a considerably higher temperature than might be desirable for the oil system.

The oil used for cooling the power cylinders is also generally used for lubrication purposes and, therefore, must be filtered for the removal of all fine and probably abrasive particles, and of sludge. Oil filters commonly use some adsorption material that tends to sweeten the oil, remove dirt and carbon particles, and any unsaturated materials that may tend to form by the heat of combustion.

With proper filtration and reclamation of the oil, its lubricating properties can be maintained for months of continuous service.

(13) Safety devices. Safety devices for compressor plants should be considered under two cassifications, these being: Instruments for the protection of the plant against overheating, etc., and instruments for the prevention of explosions where air-gas mixtures are being compressed.

Devices such as overspeed stop and safety stops, which are actuated by low lubricating oil pressure, high cooling water temperature, and subnormal cooling water flow have been in common use for several years. More recently safety devices have been available that can be attached to bearings and which will shut down the unit automatically if the bearing temperature becomes excessive or if the clearance between moving parts becomes too great. Both the output and input of the compressor can be controlled automatically to conform to changes in pressure requirements and thus prevent overloading when pressure conditions exist which might damage any part of the installation.

If the new, direct-current rectifiers, previously described, are used for engine ignition, a positive interrelated control is provided between the electric generators, water and oil circulating pumps, and engines. If electric power should fail for any reason, the compressor and circulating pump stop simultaneously, making it impossible for a compressor to overheat by running without water circulation. However, in this system each engine has its own individual rectifying unit, so an entire series of compressors need not shut down because of the failure of one ignition element, which is always a possibility when a central battery and charger system is used.

Methods for the calculation of the explosive limits of lease gas and apparatus for the determination of the same have been described in detail by Nielsen and Yuster[15] and are here referred to as being complete and adequate. In addition to the installation of flame arrestors in discharge lines and shear reliefs one of the most practical methods yet developed for the prevention of explosions is the safety cylinder, described recently by Squires[16]. When mixtures of air and gas within the explosive range are brought to the compressor plant, the safety cylinder automatically will short-circuit the entire ignition system, thereby stopping the engines immediately and shutting down the plant. Changes to safe proportions of air and gas then can be made before the operation of the plant is resumed.

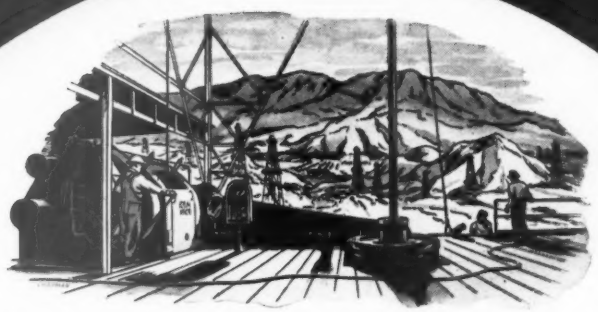
(14) Plant buildings. In the installation of any compressor station, provision should be made for the possible need for future expansion as well as for convenient and efficient operation of the machinery selected originally. A compressor needs a clean, light room, with ample space around it for cleaning of parts and inspection. Room must be available so that pistons can be removed and replaced quickly if there be need for such service, and for repair or replacement of any part of the cooling system.

As pointed out by Thiel[11], the use of medium speed engines for driving compressor cylinders has decreased the size of the buildings necessary to house the main units in a compressor station. A distance of 10 ft. between machinery and the building walls is suggested and an alleyway of 5 ft. around all moving units.

Buildings for the housing of compressors generally consist of a steel framework resting on a solid concrete basement wall that is carried up to the main floor level. Where basements are included as a part of the plant building, the floor is generally not more than 4 ft. below the grade line, which allows the compressor piping to come out of the station above grade. The outside headers are then laid on concrete supports and all outside valves are in plain sight of the station operators. Catwalks are built to each valve for the convenience and safety of the operators. A solid brick or reinforced concrete wall is carried from the floor to the top of the window sill and galvanized iron is used generally for the rest of the wall and for the roof. The windows are steel sash ventilating type and should be air-tight as possible. The installation of a travelling, overhead crane with capacity of not less than two tons will help to reduce maintenance cost.

The heating of a compressor station building can be done by an exhaust gas furnace or boiler that is supplemented by a gas or oil-fired boiler for emergencies. In areas where dust storms are prevalent, some stations are supplied with waterwashed air, which has considerable bearing upon the maintenance cost of the plant. Another recent innovation is the placing of the motor driven water pumps in a small house at the cooling tower and having them remote controlled from the switchboard in the auxiliary house. This decreases the length of the water lines and also decreases the size of the auxiliary building. The auxiliary building is of the same general construction as the main building except that it does not have a basement. In it are placed the auxiliary engines direct-connected to generators, the air starting compressors, the station

IDEAL NO. 34-10-FE DRAW WORKS



. . . Provides Outstanding Performance for a Steam Rig

The 34-10-FE Draw Works, powered by a 14 x 14 Twin Steam Engine, incorporates features that have won the whole-hearted approval of operators. Some of these features are:

No. 3⅛ API Double Hoisting Drive Chain

54" Dia. x 10⅜" Water Cooled Brake Rims

28" Dia. x 40" Hoisting Drum

Popular Type "K" Brakes

Controlled water circulation to the heat-treated rolled forged alloy steel brake rims increases their life, makes brake lining last longer and greatly improves braking efficiency.

Accurate machine-cut sprockets with flame-hardened driving faces play an important role in the increased life of this Draw Works.

The Cascade Lubrication System furnishes a continuous circulation of oil through individually controlled lines to each enclosure where it is sprayed over the chains and returned by gravity to the reservoir.

If you want dependability and economy, investigate Ideal Draw Works. They have provided outstanding performance and established many drilling records under all kinds of service conditions, in all parts of the world.

NATIONAL BLUE PRODUCTS

THE NATIONAL SUPPLY COMPANY

GENERAL SALES OFFICES: TOLEDO, OHIO · DIVISION OFFICES: CASPER · FORT WORTH
PITTSBURGH · TULSA · TORRANCE · EXPORT: NATIONAL SUPPLY EXPORT CORPORATION,
30 ROCKEFELLER PLAZA, NEW YORK, N.Y., U.S.A. · RIVER PLATE HOUSE, 12 SOUTH PLACE, LONDON, E.C.2.

office, spare parts and supplies store room, lockers, and wash room.

(15) Selection of compressor machinery. A great variety of compressor machinery is used in air and gas repressuring operations ranging from the older belt-driven types, to horizontal direct-driven, to the more modern vertical direct-driven types. Most repressuring projects, as previously stated, do not require the large, elaborate installations utilized in big pressure-maintenance projects or in the transmission of gas over long distances by pipe line. However, many of the efficient practices and economies of operation that have been developed in the larger plants can find direct and profitable application in the design of smaller units for secondary recovery projects.

Because of their light weight, the vertical, angle-type, high-speed, gas engine-driven compressors were adopted widely during the war years. Machines of this type have had excellent performance records, which combined with their flexibility and the fact that their operating cost is generally little if any more than for the horizontal type, have made them quite popular. The higher speed compressors have introduced problems of vibration that were not present in slower moving machinery, and, obviously, they require greater attention to cooling and to lubrication.

Although no installations of centrifugal compressors are known in secondary recovery work, it would seem that centrifugal compressors might be given consideration for any installation that is designed to operate with large volumes and at less than 500 lb. per sq. in. discharge pressure. Manufacturers report great efficiency and economy from centrifugal compressors in the lower pressure ranges.

In any compressor installation the use of several smaller-sized units rather than only one larger unit is preferable. Such an arrangement allows for the smallest loss in compressor capacity in the event of a breakdown of any single unit, and for the smallest investment in spare capacity. However, increasing the number of individual units increases the cost of foundations, the size of the building, the extent of the piping, inventory of spare parts, etc. Many plants are designed to operate somewhat below their rated capacity, so that if one unit should break down the same volume of gas could be delivered temporarily by the remaining units operating under full rated load.

● **IV. Construction of compressor plants.** *(1) Plant lay out.* Before the construction of any compressor plant is begun, careful attention should be given to the layout in order that all factors that will add to long range efficiency and economy of operation may be considered and utilized. A location in proximity to pumping powers and tank battery may permit some saving in labor cost. In most repressuring projects the compressor plant may be an integral part of a natural gasoline manufacturing unit, and, as such, must be situated conveniently with reference to roads and railroads as well as to producing and injection wells. Every compressor manufacturer that has been consulted has stressed the desirability of close cooperation between the manufacturer and the operator in the design and erection of a new plant. That this is both a prudent and practical recommendation, cannot be questioned.

(2) Foundations. As described by Thiel[11], the base for all compressor foundations should be a mat extending under and beyond the actual foundation unless these foundations can rest upon solid rock, in which case the foundations should be insulated from the rock by some vibration dampening material such as cork. The mat should be large enough to extend to within a foot or so from the building foundations, but should never extend to or under the building foundations as this would transmit any engine vibration to the building walls. In all cases the foundation should be carried to a depth below frost line, which should not be assumed but determined accurately by climatic conditions.

If there is any question regarding the character of the subsoil, test borings should be made in advance at the proposed location for the compressor plant and should be examined by a foundation expert who can advise regarding the size of foundation that will be required and the type of materials that should be used in its construction. Where the subsoil is weak, and particularly where it may be waterbearing, piles to support the mat, with braces to resist horizontal displacement, may be required. These piles should be driven to solid ground with the outside row of piles sloped with their tops toward the center of the mat.

All compressor foundations in any one building should be set on the mat in that building and anchored securely to it. This is the best means of eliminating any horizontal shaking forces, as the shaking forces developed by one unit will have a tendency to counteract the forces of another unless all units are synchronized, a condition that does not exist in a compressor station except for short periods of time. The lower or tension side of the mat should be well reinforced and keys should be cast into the top of the mat at those surfaces where the compressor foundations are to rest so as to tie the mat and the foundations into one solid mass.

With the compressor foundations keyed into the mat, they further should be well reinforced at all points that may be subject to tensile stress. All foundation bolts should be surrounded by a pipe or duct whose diameter is at least 2.5 times the diameter of the bolt and extends into the foundation for a distance of at least 15 times the diameter of the bolt. These ducts should be kept free of concrete when the foundation is poured. This is done to facilitate lowering of the engine base over the foundation bolts. In the case of large horizontal units where the foundation bolts are very long, the duct should run down to the foundation washer so that the bolt can be removed when the engine main frame is skidded on to the foundation.

The foundations are generally built

LUFKIN "MEZURALL" TAPE-RULE COMPACT, CONVENIENT, ACCURATE

The Lufkin "Mezurall" Tape-Rule is small and lightweight, but what a whale of a measuring job it does! Takes inside and outside measurements. The concave blade is stiff enough to be projected unsupported, yet it flexes easily around angular objects. Blade remains set at any length withdrawn. Get the best — order the Lufkin "Mezurall" through your supply house. Write for free catalog.

LUFKIN

THE LUFKIN RULE CO., SAGINAW, MICHIGAN, New York City

YOU'LL SAVE 7 WAYS WITH ELECTRIC POWER

1 LOW FIRST-COST OF POWER-DRIVEN EQUIPMENT

2 LOW OPERATING, MAINTENANCE AND LABOR COSTS

3 DEPENDABLE, DAY and NIGHT, ALL-WEATHER PERFORMANCE

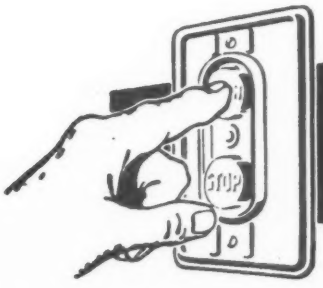
4 HIGH SALVAGE VALUE

5 EXTREME PORTABILITY

6 LESS TROUBLE, FEWER REPAIRS, SMOOTH OPERATION

7 HIGH SAFETY FACTOR

Houston Lighting & Power Company engineers will gladly discuss your power requirements for field or refinery.



HOUSTON LIGHTING & POWER COMPANY

with a step or shelf in them approximately 14 in. below the floor line, which acts as a support for the floor beams. A step or shelf may also be put in the building wall foundation for the same purpose. When the floor is poured a strip of insulating material, such as pitch-impregnated felt at least 1 in. thick, is placed between the edge of the floor and the foundations, or the gap filled with asphalt. This helps to prevent any horizontal forces or vibrations from being transmitted from the engine foundations to the building wall. Both foundation block and mat should be cast in single pours with anchors of vertical bars, or poured consecutively. Ample time should be allowed for curing of the concrete.

(3) Basement. Previously in parts of this paper the construction of a basement has been assumed. However, if a basement is not considered necessary, adequate provision must be made for laying pipe so that all flanges, valves, unions, and joints will be accessible, and the use of a pipe trench is desirable for this purpose. If a basement is decided upon, as stated by Thiel[11], it should be built high enough and the piping should be so arranged as to allow plenty of head room and working space around the piping, and should be provided with facilities for proper ventilation.

Most basements are now built with but half of their height below ground level, which allows for the installation of full size windows in the basement and makes it available for the storage of spare parts and operating stores such as oil and waste. Room for placing a bench for light repair work can also be found in the basement making it a handy place for the repair crew on rush repair jobs.

(4) Grouting. According to Thiel[11], when grouting an engine the grout should never exceed 1½-in. in thickness and should be virtually the same thickness over the entire foundation top. This eliminates excessive and uneven shrinkage, which might throw the unit out of line after the grout has dried. However, it will be recognized that grouting may vary with each individual job, and, as such is not a subject that can be treated adequately in a paper of limited scope.

● **V. Acknowledgments.** The Sullivan Machinery Corporation, The Cooper-Bessemer Corporation, and Ingersoll-Rand Company provided much information employed in the preparation of this paper. The several papers by B. C. Thiel on design and construction of compressor plants are outstanding and have been a source of much data that are incorporated herein.

T. H. Acres, W. B. Berwald, Jo H. Cable, George H. Fancher, P. E. Fitzgerald, Norris Johnston, H. J. Lowe, C. M. Nickerson, J. E. Sherborne, Frederick Squires, and S. T. Yuster, members of the Standing Subcommittee on Secondary Recovery Methods have assisted the writer substantially by helpful suggestions and constructive criticism. The assistance they have rendered is appreciated deeply.

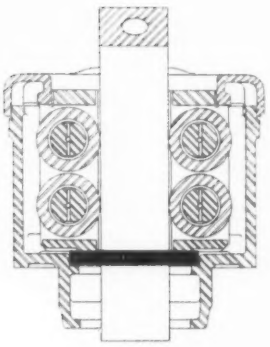
● **References.**

1. "The Criteria for Determining Oil Fields' Susceptibility to Secondary Recovery Methods", API, First Supplement to "Secondary Recovery of Oil in the United States", 1943.
2. R. C. Earlougher, AAPG Symposium on Secondary Recovery, 1943.
3. "Air and Gas Repressuring in Pennsylvania", R. B. Bossler and Parke A. Dickey, API, "Secondary Recovery of Oil in the United States".
4. "Gas Repressuring in the State of Texas", Jo H. Cable, API, "Secondary Recovery of Oil in the United States", Jo H. Cable. Also see API First Supplement to "Secondary Recovery of Oil in the United States" in Chapter on "Preliminary Tests".
5. "The Development and Operation of Gas Repressuring Projects", Paul D. Torrey, API, "Secondary Recovery of Oil in the United States".
6. "Air and Gas Compression", T. T. Gill, John Wiley and Son, 1941.
7. "Effect of Supercompressibility of Natural Gas Upon Compressor Performance", Robert S. Ridgeway, *The Oil and Gas Journal*, May 12, 1945, pp. 104-118.
8. "Calculating Pipe Sizes for Compressor Cylinders", B. C. Thiel, *The Petroleum Engineer*, November, 1943, p. 135.
9. "Controlled Water Jacket Cooling Reduces Maintenance Costs", B. C. Thiel, *Petroleum Refiner*, Vol. 23, No. 6, pp. 197.
10. "Modern Compressor Station Design," Harold F. Dawe, *The Petroleum Engineer*, April, 1945, p. 75.
11. "Gas Compressor Station Design", B. C. Thiel, *The Petroleum Engineer*, February, 1944, p. 151.
12. "Correcting Problems Caused by Scale and Corrosion in Compressor Stations", Paul V. Sanders, *The Petroleum Engineer*, March, 1945, p. 208.
13. "Control of Compressor Cooling Water", E. G. Hammerschmidt, *The Petroleum Engineer*, March, 1945, p. 192.
14. "Modern Compressor Stations", B. C. Thiel, Paper published by The Cooper-Bessemer Corporation, Mt. Veron, Ohio.
15. "Explosive Mixtures on Air Drive Operation", R. F. Nielsen and S. T. Yuster, *The Petroleum Engineer*, June, 1945, p. 96.
16. "The Principle of the Safety Cylinder as an Explosion Preventer in Air-Gas Compression", Frederick Squires, Illinois Geological Survey, Circular 93, 1943.

★ ★ ★

Install Them and Forget Them!
AMERICAN
RADIAL
Roller Bearings
AMERICAN RADIAL ROLLER BEARINGS are engineered to exacting standards that result in better performance and minimum maintenance.
Furnished in 5 styles, 6 S.A.E. series and 85 sizes. Special designs also available. Write.
AMERICAN ROLLER BEARINGS HEAVY DUTY
AMERICAN
ROLLER BEARING CO.
420 Melwood Street Pittsburgh, Pa.
Pacific Coast Office:
1718 S. Flower St., Los Angeles, Calif.

How to keep your Kelly clean and save Drive Bushing Roller wear

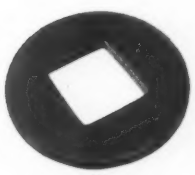


RUBBER WIPER CONTACTS KELLY

Kelly drive bushing manufacturers are often the best boosters for Patterson-Ballagh Kelly Wipers. They know from experience the value of preventing mud abrasives from going through the rollers. These rollers are subject to severe impact whenever rotation is started and their wear rapidly increases when mud is allowed to be carried through them by the Kelly. Patterson-Ballagh Kelly Wipers, installed in the Kelly Bushing, wipe the Kelly clean and dry to avoid carrying abrasive materials into the rollers. The mud and cuttings have no chance of being forced into the Kelly Bearings where they may harden and lock the rollers, making necessary early replacement. Many manufacturers have redesigned their bushings to accommodate a Patterson-Ballagh Kelly Wiper, which is furnished with the assembly.

Crews often find it difficult to clean the Kelly while drilling with oil base fluid. The Patterson-Ballagh Kelly Wiper eliminates this difficulty and helps to keep the premises clean and free of fluid drippings.

Kelly Wipers act on the same tension principle used in Patterson-Ballagh Pipe Wipers. They are installed in the manner shown in the drawing on the right. In addition to saving roller wear, they prevent added roller friction and help the operator by improving the ease of movement of the Kelly, resulting in more accurate reading of the weight indicator. Eliminating the need for wash water prevents mud dilution from that cause. Patterson-Ballagh Kelly Wipers save enough to repay their cost in a very short time.



WIPER FOR SQUARE KELLYS

WIPER FOR HEXAGONAL KELLYS

PATTERSON-BALLAGH SEAL OF QUALITY OIL FIELD SPECIALTIES

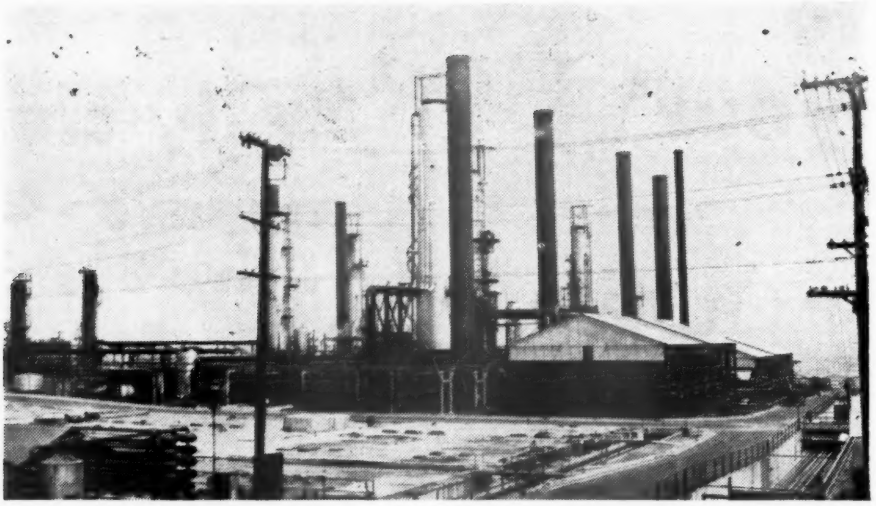
Specify

PATTERSON-BALLAGH

DIVISION OF BYRON JACKSON CO.

KELLY WIPERS

Main Office: 1900 E. 65th St, Los Angeles 1, Calif. ★ 6247 Navigation Blvd., Houston 11 ★ 808 Graybar Bldg., New York 17 ★ 931 Russ Bldg., San Francisco 4



Crude distillation and combination cracking section of Union Oil Company's plant at Wilmington, California.

Insulating refinery equipment

By JOHN C. ALBRIGHT

EXCLUSIVE

WITHOUT a coherent system of insulating refinery equipment, stocks of material have been known to accumulate, leaving on hand a mass of supplies that cannot be worked into future installations nor disposed of to any appreciable advantage. This problem has been faced by many organizations to the distress of the storekeeper, and, together with other equipment of greater potential value, has been written off the books after sale at a nominal price. On the other hand, when a concise and intelligent set of insulating specifications is prepared, and men trained to install the insulation, the surplus stocks are of a quantity necessary only to repair covering removed during a shutdown.

"Way back when" Union Oil Company of California was building individual units for continuous distillation, cracking, and treating petroleum and its products in the Wilmington, California, refinery, a precise and well laid out system for insulating equipment was established so that any covering applied to vessels and pipe lines would provide the anticipated protection and conservation of heat. How advantageous this system has proved can be shown by the length of life and efficiency of the insulation, and the number of times the initial covering can be used.

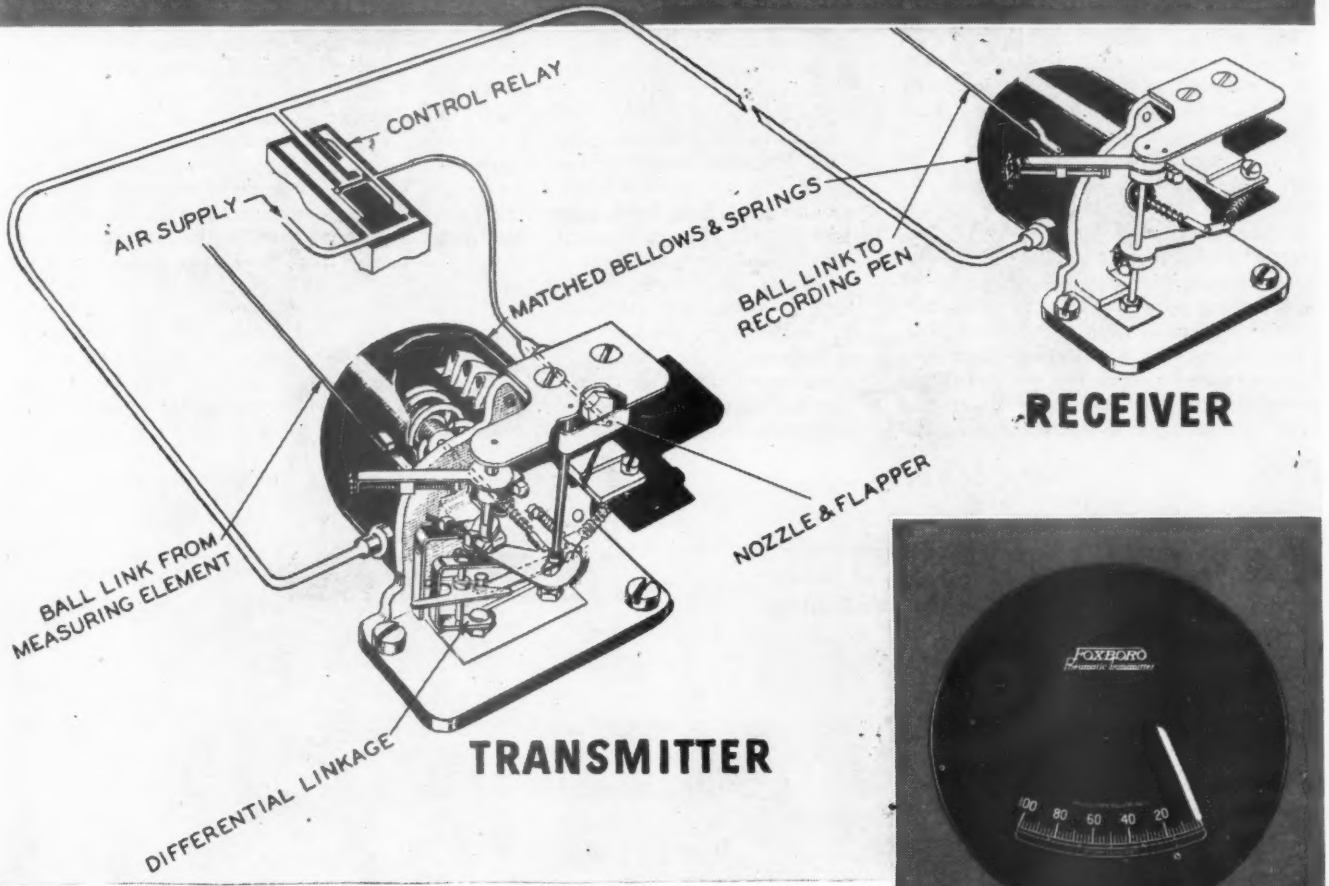
One of the many examples of results that have been obtained in the Wilmington plant can be illustrated by the long operating life of a certain processing column originally erected in 1929. This column was covered with blocks of high temperature insulation, installed according to Union's specifications and protected from the weather with a finish coat. The unit and column were operated continuously from 1929 until 1936 when repairs to the upper part of the column shell were required. The original insulation covering the tower was removed by company men trained in the art of applying insulation, who practiced dexterity and exercised concern for the material while it was being removed, lowered to the ground level, and stacked. After repairs had been completed, this original insulation was reapplied according to company specifications and subsequently remained in place with no major repairs until the unit to which the column was attached was shut down permanently in 1946, providing a total of 17 years of effective insulation at approximately the original expenditure for equipment and material.

The insulation specifications as established by Union Oil Company are divided into general and specific sections, with the top and No. 1 item concerned with the safety and well being of refinery employes. The first paragraph reads as follows: "All equipment, columns, interchangers, valves, and pipe lines carrying hot oil vapors or steam, in which it is desirable to conserve heat, or in which it is necessary to maintain temperature, or hot lines and equipment installed in such position that they may be touched by an operator during the performance of his duties SHALL BE INSULATED."

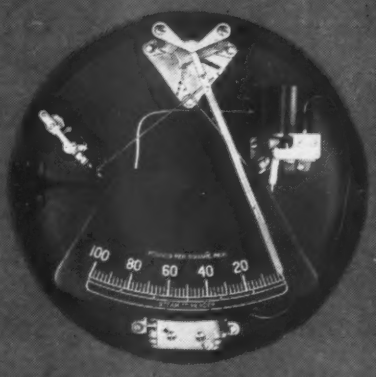
All vertical vessels that are to be insulated are provided with circumferential insulation supporting rings, made of ¼-in. angle iron with the legs in all cases ½ in. shorter than the thickness of the material that is to be applied. These rings are tack-welded to the vessel, beginning at the skirt seam, with the legs pointing upward. The distances between the rings vary according to the operating temperature of the vessel. When temperatures do not exceed 500 F maximum, the rings are spaced on 12½ in. c-c, but on vessels that are to be operated with temperatures exceeding 500 F, the rings are applied with a spacing of 6½ in. c-c, plus or minus, in order to miss nozzles and brackets for ladders and other auxiliary equipment attached to the exterior of the vessel or column. To retain the insulation in place on bottom heads and around necks and nozzles, clips are tack-welded in such manner that the blocks may be securely fastened to prevent slipping and slumping during operation of the columns or vessels.

Application of the material, whether 85 per cent magnesia or high temperature blocks, is accomplished in such

NEW, ADVANCED DESIGN IN PNEUMATIC TRANSMISSION!



The New Foxboro Pneumatic Transmitter . . . for flow, pressure, temperature, liquid level, etc.



Inside view, showing simple construction, complete accessibility of parts.

FEATURING *linear calibration,* the new Foxboro Model 42 Pneumatic Transmission System introduces a new standard of accuracy in long distance measurement of process variables. Transmitter and receiver elements are made to a master calibration standard, assuring precise readings at one or more distant points, with perfect interchangeability of units.

This new transmission system also features a newly designed reference (zero) arrangement which permits adjustment of the indicating pointer without affecting transmitter calibration . . . large, easy-to-read scales . . . standard Model 40 air relay and exclusive ball linkage.

Transmitters are furnished in a standard 12" indicating case, illustrated at the right. Receivers are supplied in indicating or recording models, or the receiver unit may be used as the primary element in any Foxboro air-operated or electric-operated Controller.

The new Foxboro Transmission System is available for flow, pressure, temperature, liquid level, humidity, etc. For complete details, write **The Foxboro Company, 130 Neponset Avenue, Foxboro, Mass., U.S.A.**

FOXBORO
REG. U. S. PAT. OFF.

PNEUMATIC TRANSMISSION

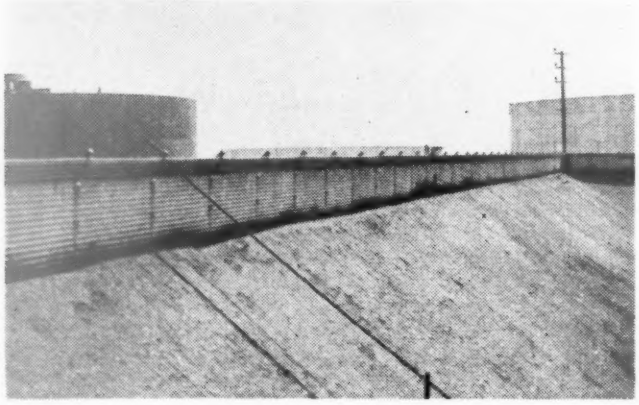
manner that no two joints will coincide, and all spaces between the blocks are chinked or otherwise filled with scraps of self material ground to a consistency that it can be worked into the interstice, as one would use mortar, without leaving uneven spots and depressions so that subsequent coats of protection can be applied, leaving a smooth, even surface. Prior to the application of the smoothing coat, the blocks of insulation are retained and banded with at least six No. 14 gauge black annealed wire for each 3-ft section. After sealing the crevices between individual blocks, the insulation is further reinforced with chicken wire, 20-gauge galvanized with 1-in. hexagonal mesh. Joints and courses are lapped to not less than 3 in., and the wire laced and stapled to maintain the original tautness. A finish covering, having a thickness of not less than ⅛ in. after drying, is trowled smoothly over the reinforcing wire so that any roughness in the surface is obliterated. If the column is exposed to exterior conditions where temperature or the weather might eventually break down the finish coat, a sheating of metal is applied, using 26-gauge galvanized sheet. This is securely attached to the column insulation to prevent creep and has adequate vertical and circumferential laps to shed rain. Expansion bands are attached to the adjacent ends at the vertical seam for drawing together with spring loaded bolts to compensate for circumferential expansion. Manhole covers on columns opened frequently for internal inspection and cleaning are fitted with a metal ring attached to the cover in such a position that impact wrenches may be used conveniently to remove the nuts without damage to the insulation.

In 1940, personnel listed as working in industrial research laboratories numbered 70,000. By 1946, this group had increased to more than 133,000 individuals in such work.

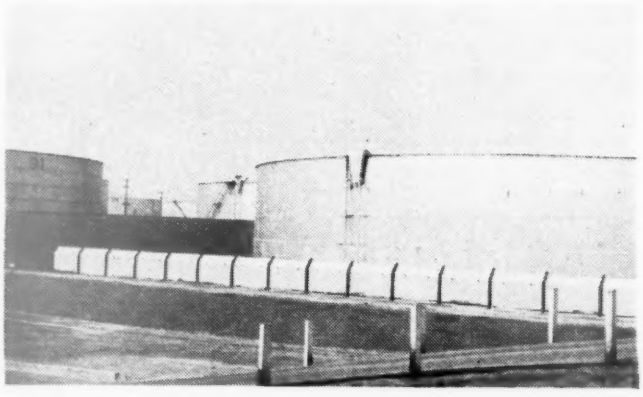
☆ ☆ ☆

Insulation applied to pipe lines operating under conditions where temperatures exceed 500 F is provided with expansion joints at not more than 25-ft intervals, and at tangents and sharply turned ells. Vertical lines are fitted with lugs to support the insulation to prevent creep. These lines are spaced so that at least one bolt's length is left free near flanges so that no obstruction exists that might interfere with ease in taking bolts from flange holes. Piping of a permanent nature is weatherproofed by one of three different methods, depending upon the locaton and exposure to abrasion and the effects of weather. The first method follows the practice used on vertical columns, using hexagonal woven wire and finished with a weather coat, applied in a manner to obtain a thickness of not less than ⅛ in. after drying. The covering is reinforced before the application of the wire mesh by using 18-gauge wire placed with at least four wires for each 3-ft section on all pipe of 1-in. diam and smaller. Pipe from 1 in. to 12 in., inclusive, is wired with not less than 16-gauge wire, and pipe more than 12 in. in diam is reinforced with not less than 14-gauge wire. Another method is that of covering the finished insulation with 45-lb asphalt saturated felt, shaped to fit snugly the contour of the pipe and lapped at all

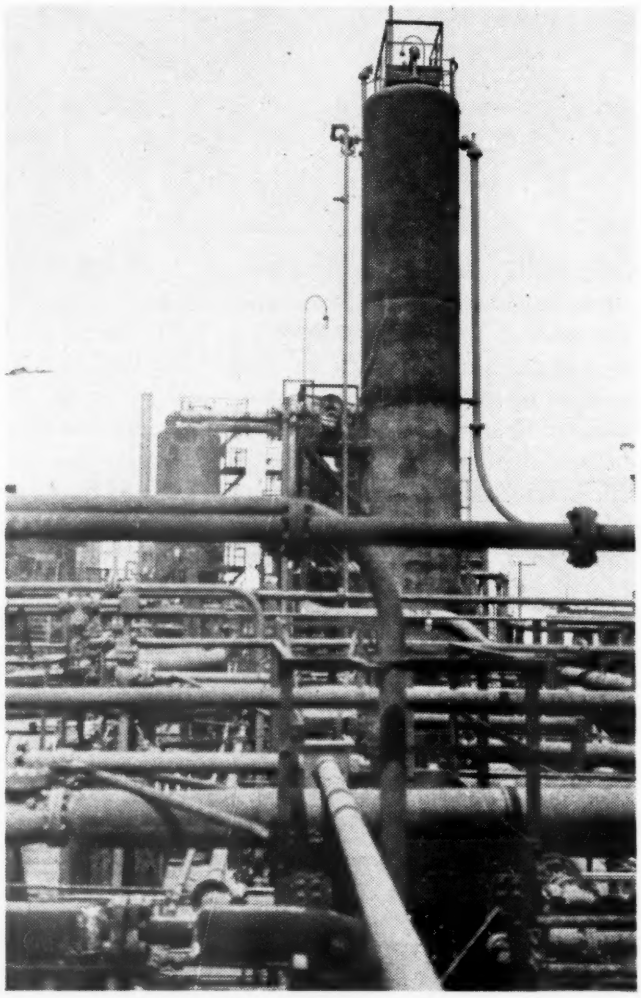
Inside of firewall showing flare of transite to prevent rolling of inflammable liquids.

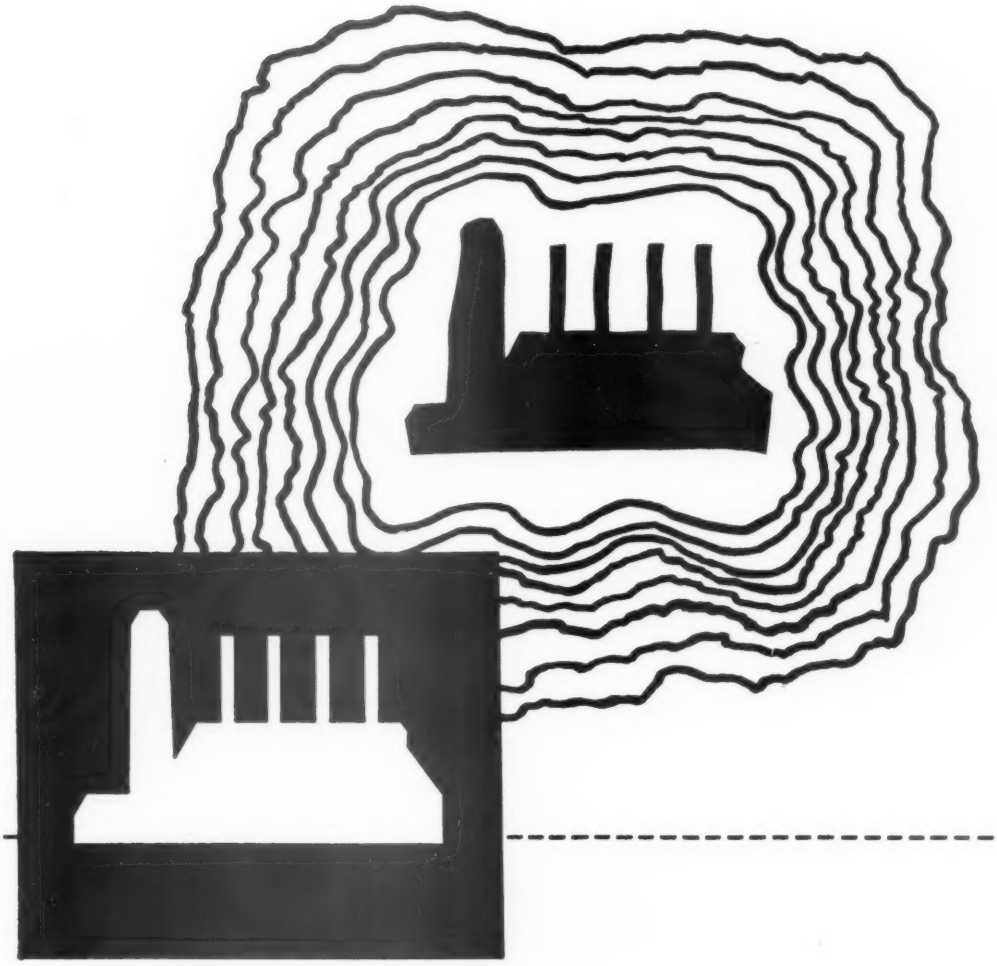


Outside of firewall showing transite corrugated wall in Union tank farm.



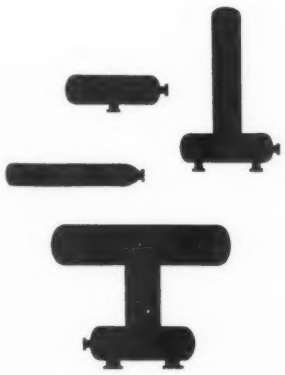
Fractionating column originally insulated in 1928, later stripped and reinsulated with same material, gave service for 17 years.





R_x for Plant Palsy*

* *Due to pulsative gas flow*



Fluor Pulsation Dampeners are "tailor-made" to fit every specific requirement.

"Plant Palsy"... vibration due to pulsative flow in gas, air or vapor pipe lines... is an entirely too frequent industrial ailment.

The ideal prescription for this malady is the Fluor Pulsation Dampener. It converts pulsative flow into a smooth, steady stream. It reduces friction losses. It permits stepped-up rate of flow It increases horsepower efficiency. Pipe line breakage due to excessive vibration, with subsequent danger of explosion and costly shutdown, is largely eliminated. Moreover, accurate meter readings are made possible. The unit has no moving parts; hence no maintenance attention or expense.

If your plant is suffering from "palsy" due to pulsative flow, let Fluor show you the effectiveness of the Fluor Pulsation Dampener... as proved by hundreds of satisfactory installations!

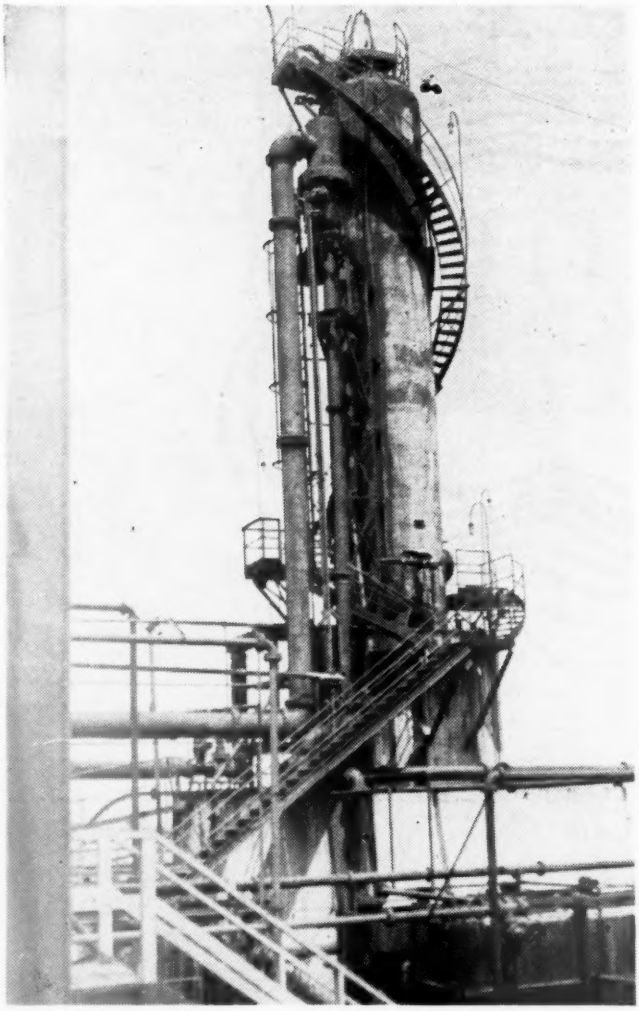
FLUOR

PULSATION DAMPENERS

PRODUCTS *Cooling Equipment, Mufflers, Gas Cleaners, Pulsation Dampeners*

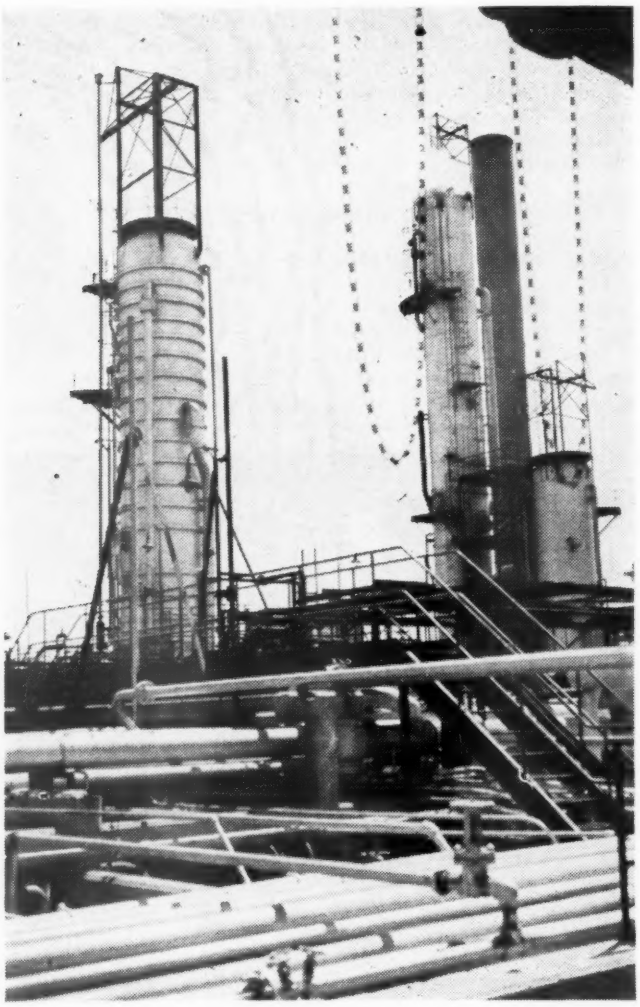
SERVICES *Designers and Constructors of Refinery, Chemical and Natural Gas Processing Units*

THE FLUOR CORPORATION, LTD., *Los Angeles 22* · NEW YORK · PITTSBURGH · KANSAS CITY · HOUSTON · TULSA · BOSTON



Vacuum distillation unit where in Union Oil plant insulation has remained unimpaired since 1930.

Section of modern unit showing rings around column to support insulation. (Union of California).



joints for effective protection from falling water or rainstorms. This type of covering is secured to the insulation and the pipe with 16-gauge galvanized wire twisted tightly and cut to leave approximately ½ in. of the twist, which is bent sharply parallel to the circumferential wire and tucked under so that no "wickers" or barbed ends may injure employes or tear clothing. Pipe that is exposed to heavy foot traffic, heavy streams of water, and high external temperatures is completely covered with 26-gauge galvanized sheet metal, lapped at all joints to shed water and protect the insulation, and securely fastened to the insulation with Kalon or sheet metal screws.

On all piping where flanges are opened frequently, the insulation is beveled back at an angle of 25 deg at least one bolt length on either side of the flange so that impact and open end wrenches may be used easily. Another method is to apply the insulation near the flange in sections so that removal may be accomplished without damage to the insulation. The sections are of different length, depending upon the size of the flange bolts. Where bolts are 1 in. and smaller, the removable sections are 24 in. long, and where bolts are larger than 1 in., the sections are at least 30 in. long. These sections are applied with retaining bands so the covering can be removed with the least difficulty, and reapplied to obtain maximum efficiency of the pipe insulation.

Pipe lines equipped with a single steam tracer are supplied with sheet metal angle strips formed and applied to provide the necessary air space. Lines requiring a double tracer have sheet metal channels applied in like manner for the same purpose. All fittings, meters, and instruments on process lines, together with control valves that require insulation, are first covered with a substantial wire cloth, similar to hardware cloth, to receive and support the insulation. Insulation is applied in a plastic, or mortar consistency, troweled to the required thickness and finished with waterproofing, the type of which depends upon the service for which the equipment is intended and its exposure to exterior conditions.

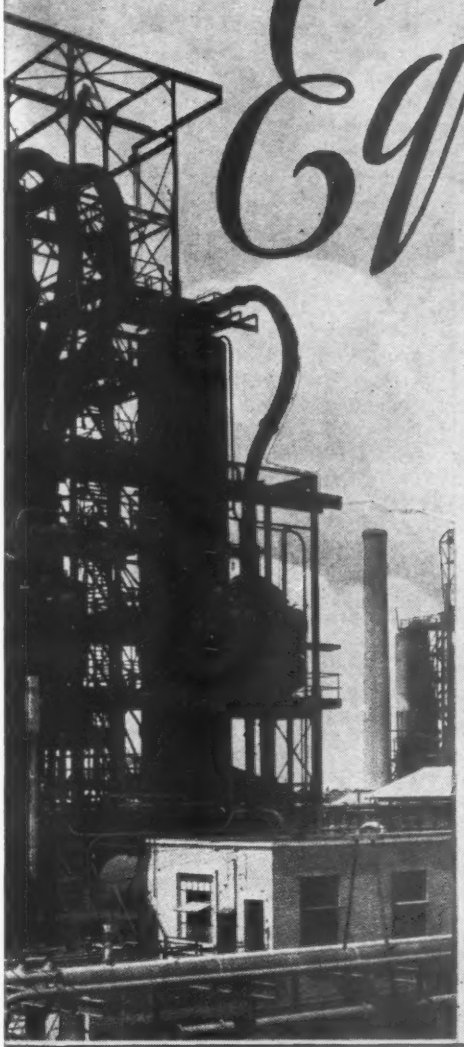
Tanks that are insulated to retain the temperature of the contents have circumferential expansion joints at not less than 75 ft intervals. The support for the tank insulation is provided by a concrete, or brick, curb at the ground level, and the top is protected from infiltration of moisture or petroleum liquids by a welded steel flashing attached to the top of the shell of the vessel. Firewalls are made by setting steel posts in the soil on the tank area dikes with the top section of the posts placed at an angle to roll back any flames or boiling products. Fireproof, corrugated transite board is fastened to the upright and angle standards with heavy bolts with large washers beneath the bolt heads or nuts. The corrugations are horizontal to break any surge that might roll against the wall.

★ ★ ★

☆ ☆ ☆

It is believed that although the 32 largest oil companies have a four-to-one lead in reserves, it's two to one that the independent operator will find the new field and better than three to one that he will drill the exploratory well.

OIL REFINING AND CHEMICAL PLANT *Equipment* MADE TO ORDER



Pressure Vessels

Towers

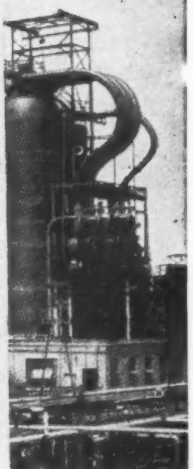
Tanks

Plate Work

Special Machinery

ANY ALLOY . ALL CODES

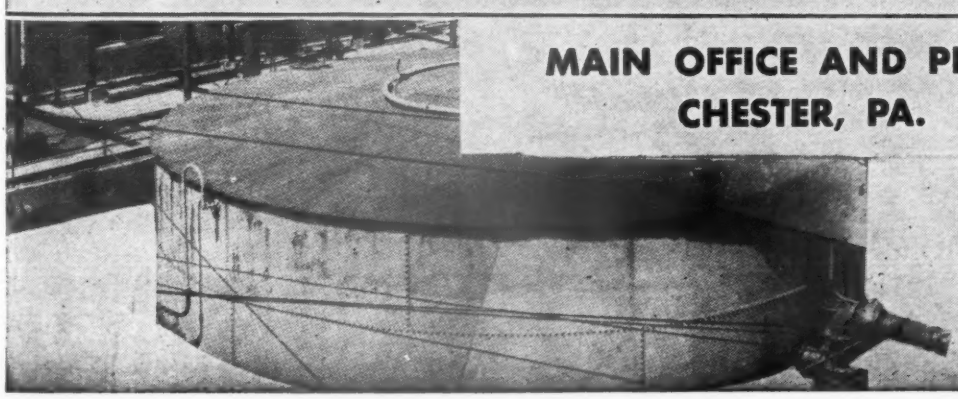
Rail and Water SHIPMENTS



SUN SHIPBUILDING AND DRY DOCK COMPANY

Since 1916

MAIN OFFICE AND PLANT
CHESTER, PA.



USNR

JOIN

New acidizing equipment designed for portability

NEW mobile acidizing equipment for oil and gas wells has been announced.* The unit is pulled by a standard truck tractor†. Hydraulically operated landing gear can be lowered and the tractor unhooked. The trailer is a complete acidizing unit in itself.

The unit has many unusual features; for example, magnesium, which is the lightest structural metal available today, is employed in the pump housings. This reduces the weight of the pumps more than 2000 lb. The pump on this particular unit can be operated against pressures as great as 6000 psi. Another pump is available that can be used for pressures as great as 8000 psi. The pressure and delivery rates of these pumps are determined by the head and piston sizes.

Cast steel used in the pump cylinders is heat treated. Two 451 cu in. displacement, 130 hp International motors with compound chain drive drive the pumps. The unit carries sufficient gasoline to operate the pump continuously for a whole day. A 1000 gal acid tank made of high corrosion resistant Yoloy steel is mounted on the end of the unit. The complete unit with tractor has eighteen 10 by 20 in. tires on the ground.

*By Dowell Incorporated, Tulsa, Oklahoma.
†International, model K-11-F.

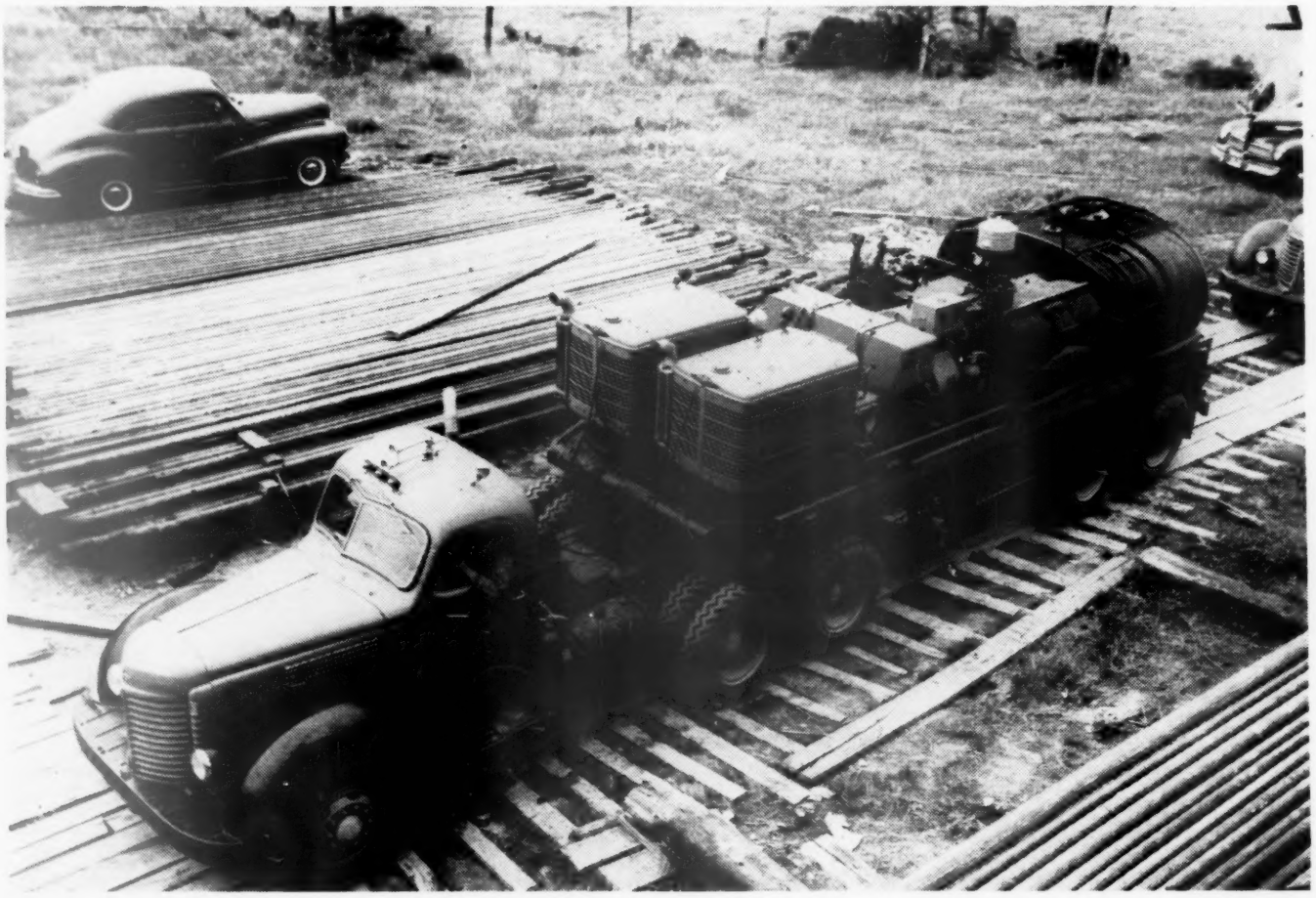
Several safety devices are embodied in this new unit. For example, the exhaust from the engines is designed for safety from sparks. The unit is equipped with CO_2 fire extinguishers. A large first aid kit is placed conveniently on each unit. It contains all standard equipment, including fire blankets. The unit is lighted adequately for safe night operation, and all moving parts are protected by steel guards. Cool drinking water is provided for the crew by a large water cooler.

The new unit is designed to deliver twice as much acid or chemicals at high pressure as the Dowell unit previously employed for this purpose. The two 130 hp motors supply the power needed to operate the large pumps.

As it is necessary to have many tools and extra fittings for well acidizing treatments, large tool boxes are mounted on each side of the unit. For emergencies, a large winch is mounted behind the driver's cab.

Assembly line manufacturing facilities have been established so that more similar equipment can be manufactured in a shorter time. New type transports and more versatile units for each particular well condition are being planned as a result of this equipment manufacturing program. ★★★

One of the new trailer-mounted mobile acidizing units being pulled over a board road by a truck tractor to acidize a new well. The tank on the rear of the trailer holds 1000 gal. of acid. Additional acid is hauled in tanks on the two truck trailers that follow.



SCHLUMBERGER

RadioActive

DEPTH MARKER

...the final measure of accuracy in gun PERFORATING

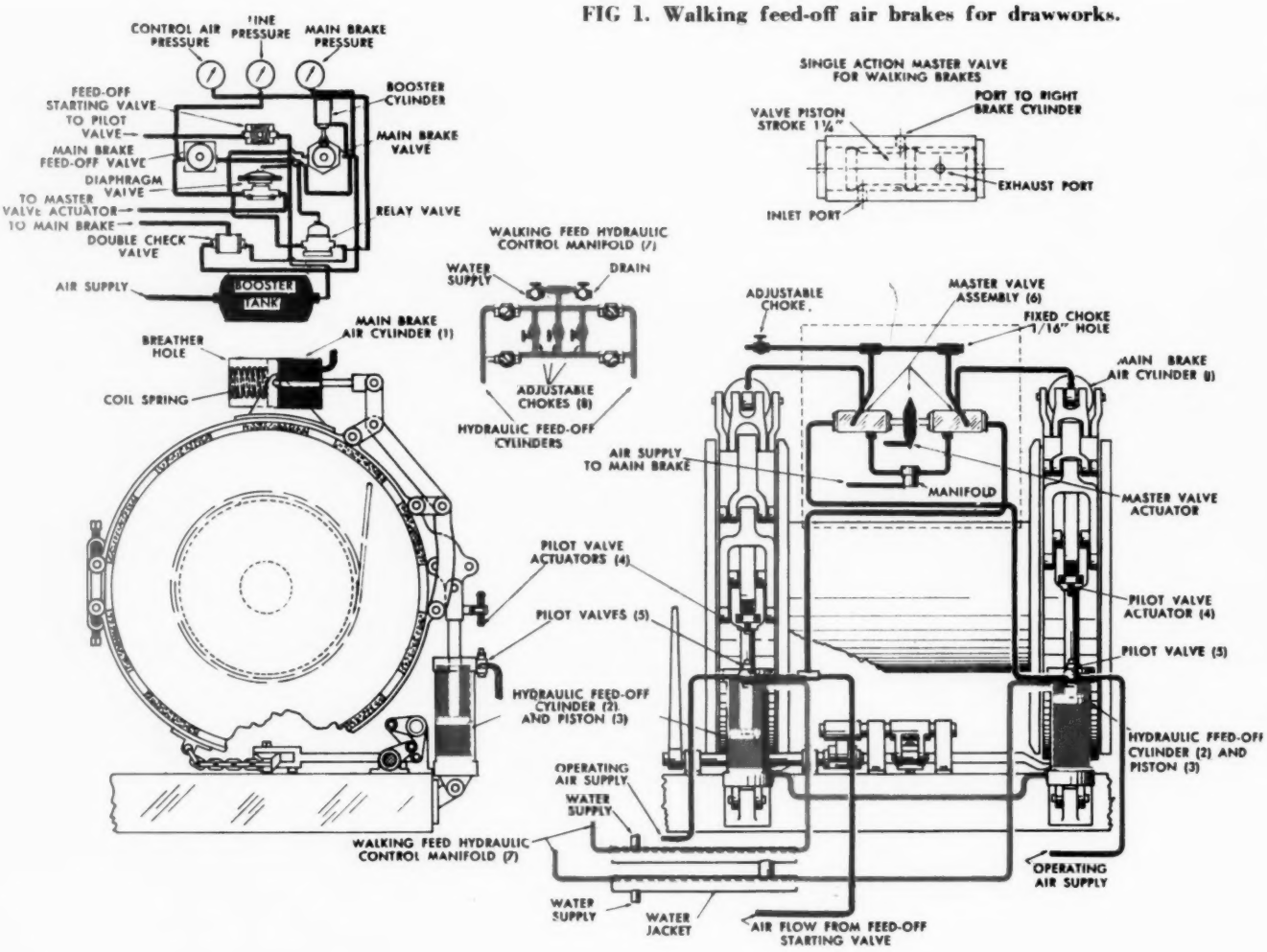
Here's how it works: A bullet (marker) containing radioactive material is placed in the formation adjacent to a reservoir. Its exact position with respect to the reservoir is determined by a regular electric log made simultaneously with placement of the marker. After casing is set, the marker is located by a radioactivity detector and, since its position with respect to the reservoir is known from the log, perforations can be made with extreme precision. As many as 18 markers may be placed at different levels on a single trip into the well.

Specify Schlumberger Precision Gun Perforating for your wells and be assured of the most efficient service available.

SCHLUMBERGER WELL SURVEYING CORP.

HOUSTON, TEXAS

FIG 1. Walking feed-off air brakes for drawworks.



Automatic drilling control*

By MARTIN E. TRUE[1] and R. R. CROCKSTON[2]

● **Abstract.** To maintain a uniform weight on the drill bit when drilling in uniform or broken formations mechanical equipment other than the drawworks friction brakes is required. A new type of feed-off mechanism referred to as walking feed-off air brakes recently developed is comprised of a combination air brake and hydraulic system. Apparatus has been developed for automatically controlling feed-off of drill pipe with the walking feed-off air brakes or other feed control mechanisms. The automatic drilling control equipment provides means for (1) actuating the hydraulic feed-off orifice valves on a hydraulic feeding device, (2) taking weight shown on the weight indicator to control the automatic feed-off mechanism, (3) automatically stopping feed-off when weight on the drill bit reaches a maximum predetermined amount, (4) automatically shifting the automatic control from weight to drill pipe torque when the torque reaches a predetermined value, (5) indicating and recording drilling rates, and (6) governing rotary speed with remote controls for regulating governor.

Martin E. True

● **Introduction.** The fundamental principles required for boring a hole into the earth's formation in search for oil or gas are no different from drilling a piece of metal or other material in the machine shop. The identical factors are involved and the general details of operation must be served. The primary factors involved in efficiently boring a hole into any material are the boring tool or bit, rotation of the tool, pressure or weight applied to the cutting tool, removal of the cuttings from the path of the cutting edge, and cooling of the bit. These factors must be maintained at their highest proper value consistent with a balanced relation between them.

This article discusses means and methods for maintaining automatically predetermined weight on bit and bit rotating speed. Careful regulation of the weight on a rotary bit is considered a vital requirement to produce the most economical drilling rates. The need for automatic drilling control equipment becomes more important when drilling to greater depths and with the use of heavier equipment.

It is desirable that the pressure or weight applied to the bit for any forma-

*Presented before American Association of Oilwell Drilling Contractors, Long Beach, California, October 13-15, 1947.

[1]Humble Oil and Refining Company.

[2]Consultant engineer.

LARKIN PACKER COMPANY

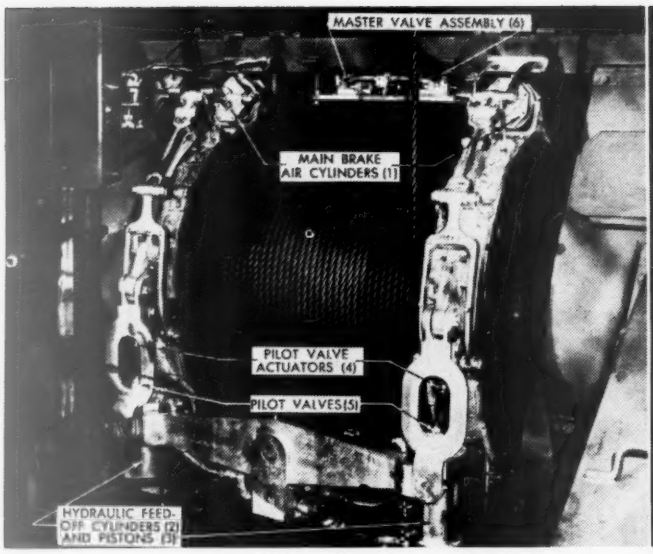

MASTER VALVE ASSEMBLY (6)
MAIN BRAKE AIR CYLINDERS (1)
PILOT VALVE ACTUATORS (4)
PILOT VALVES (5)
HYDRAULIC FEED-OFF CYLINDERS (2) AND PISTONS (3)

FIG. 2. Drawworks equipped with walking feed-off air brakes.

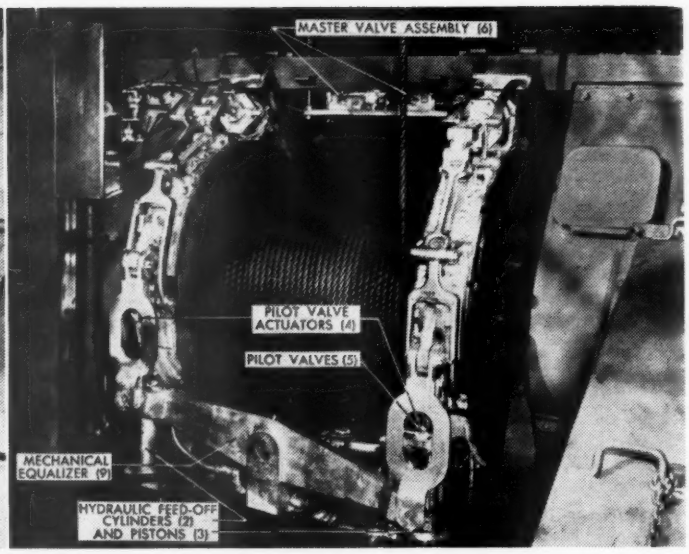

MASTER VALVE ASSEMBLY (6)
PILOT VALVE ACTUATORS (4)
PILOT VALVES (5)
MECHANICAL EQUALIZER (9)
HYDRAULIC FEED-OFF CYLINDERS (2) AND PISTONS (3)

FIG. 3. Same as Fig. 2 with right hydraulic piston in bottom position.

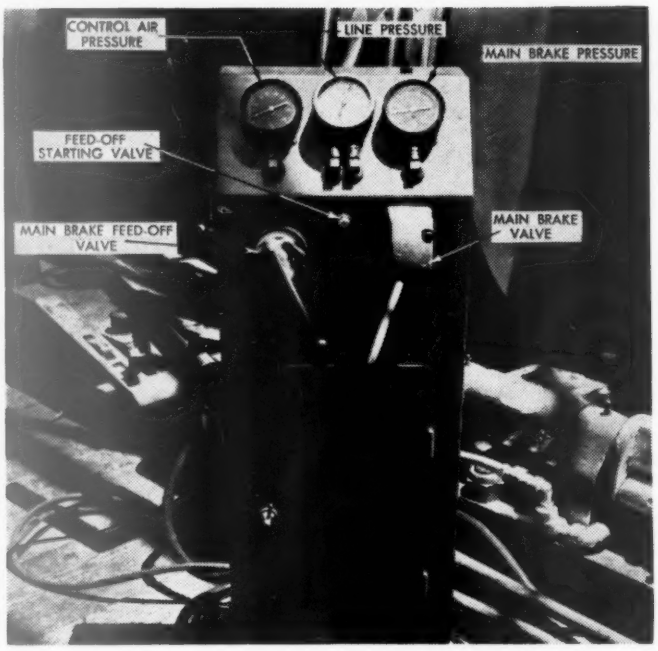


FIG. 4. Walking feed-off air brake control panel.

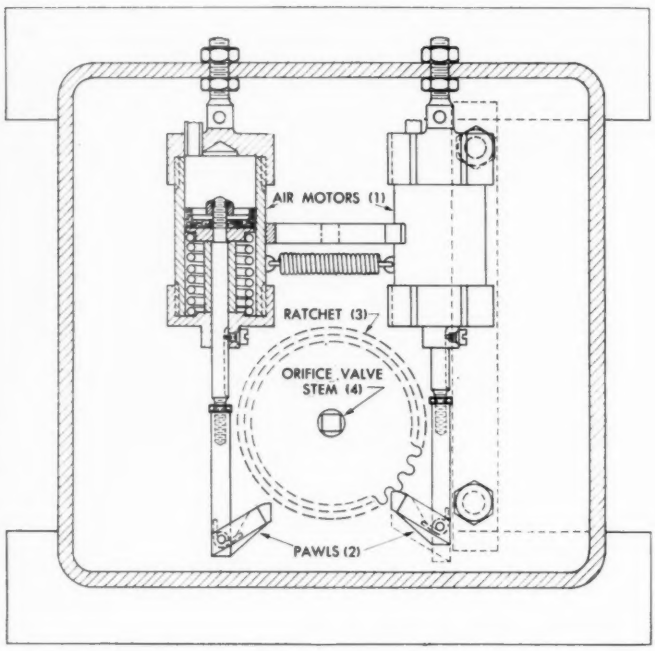


FIG. 5. Hydraulic orifice valve actuator.

tion be maintained at a uniform value. Consequently, it is important to vary the rate of feed-off when drilling in formations having streaks of varying hardness to maintain uniform weight on the bit to drilling the maximum amount of hole. If a uniform pressure is not continuously applied, there will be periods of insufficient pressure and excessive pressure on the bit. As in the case of drilling steel in the machine shop when the pressure on the cutting edge of the bit is insufficient, the tool cannot penetrate the substance being drilled to a depth for which the cutters were designed, resulting in a low rate of penetration. Wear of the bit, in general, under these conditions is as much or more than with proper weight. Excessive weight on the bit will result in rapid wear and perhaps breakage of the cutting edges. The excess weight may also produce hole deviation in addition to causing an excess load on the drill pipe and drill collars immediately above the bit, increasing twist-off hazards. Constant rotary speeds for any chosen conditions are likewise considered an important factor in obtaining the most economical drilling rates.

The control of drilling feeds on conventional rotary drilling rigs accomplished by the hand-feeding method is a manual operation and is subject to wide variations depending entirely upon the skill and alertness of the driller. The weight indicator serves as a guide to the operator for regulating the force applied

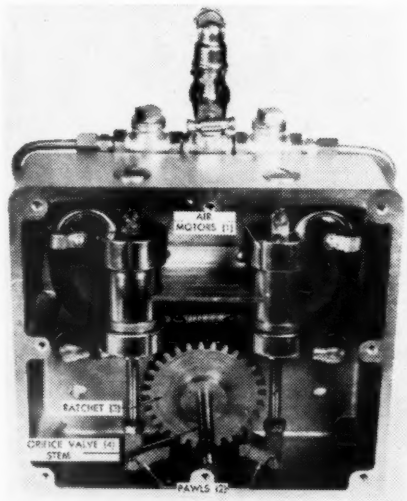
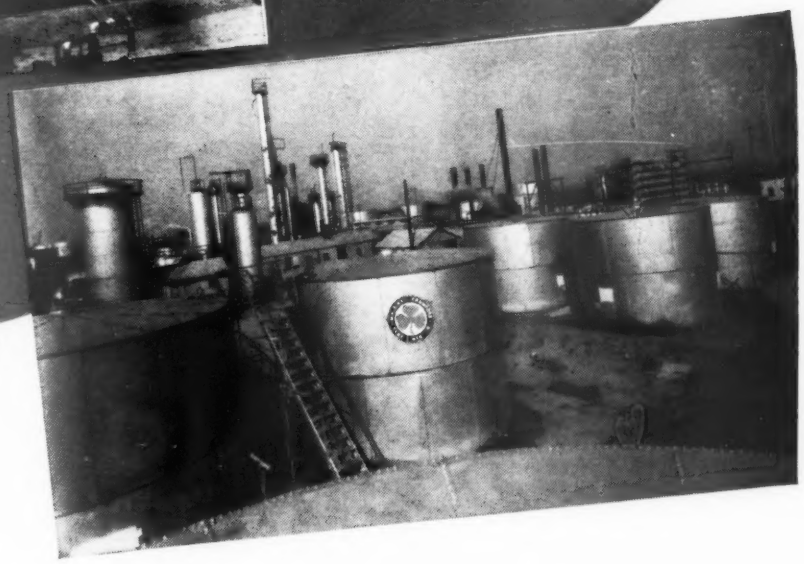


FIG. 6. Hydraulic orifice valve actuator.

In the Field or

In the Refinery...



WHEREVER LONG-LIFE TANKS ARE USED YOU'LL SEE THE MALONEY-CRAWFORD TRADEMARK

Maloney-Crawford Bolted Steel Tanks are fabricated of highest quality materials available. All parts can be furnished galvanized by the hot dip process, after fabrication, insuring complete protective coating. The Maloney-Crawford tank painting process provides a superior bonded, double-coated surface, designed for permanence. Each sheet is oven-heated by the exclusive Maloney-Crawford process to 700° F. to remove all moisture, film, scale and foreign matter. While sheets are still hot, they are painted with a special chromic primer, followed by a second coat of highest grade aluminum containing a special rust inhibitor.

Stocks and Service at Artesia, New Mexico; Tulsa, Oklahoma; Corpus Christi, Houston, Odessa and Pampa, Texas; Delhi, New Orleans and Lafayette, Louisiana and Brookhaven, Mississippi.

Write for Catalog

MALONEY-CRAWFORD TANK & MFG. CO.

P. O. BOX 659 **TULSA, OKLAHOMA**

Export Representative: JOHN H. BAIRD, 420 Lexington Avenue, New York 17, New York

to the friction brake lever of the drawworks. At best, the feed with the hand brake is irregular. The importance of providing an automatic means of eliminating the irregular feed and of maintaining a constant bit pressure increases with depth because the formations are usually harder, the drill pipe driving the bit is under greater stresses, and round trips are more time consuming. Also, the equipment required for greater drilling depths is heavier and less sensitive to the feel of the operator.

The use of bits set with diamonds or other hard materials has emphasized the need for equipment that will provide a regular uniform weight.

Drilling rate studies have stressed the importance of controlled weight on drill bit. To maintain automatically a uniform weight on the drill bit when drilling in uniform or broken formations mechanical equipment other than the drawworks friction brakes is required.

● **Walking feed-off air brakes.** A new type of feed-off mechanism recently has been developed to overcome the disadvantages of the conventional hand-feeding methods, to decrease the amount of physical effort required for operations of heavy drawworks, and to improve operating safety. This equipment is referred to as walking feed-off air brakes and is manufactured for installation on all types of drawworks. This braking system not only includes a feed-off feature but provides air-operated brakes that greatly reduce the amount of physical effort required for operating drawworks during round trips and produces considerably more power for applying the brakes in emergency cases, thus greatly improving operating safety. The braking system is designed for installation on conventional type drawworks without making major changes or sending the drawworks to a machine shop. The system is designed with an emergency power absorption capacity of 10,000 bhp, taking into account a possible "live line" tension of 100,000 lb, live line travel of 3300 fpm, drum speed of 425 rpm, and an assumed coefficient of friction of 0.4 for the main brake material. The walking feed-off air brakes, shown in the schematic drawing, Fig. 1, and photographs, Figs. 2 and 3, are more complicated in their operation and constitute considerable change from the present drawworks braking system.

This method consists of an air system shown in red in Fig. 1 that actuates the brake bands and a closed hydraulic system, shown in green, that operates alternately the right and left brakes during the feed-off while drilling. With the hydraulic cylinders in the neutral position, the operation of the air brakes is accomplished by 110 psi air pressure controlled by air valves situated on a control panel shown in Fig. 4. The brake air control panel is placed on the derrick floor convenient to the driller. When the brakes are set for feeding off the drilling line, the rotation of the brake drums is regulated by the closed hydraulic system shown in green in Fig. 1.

The operation of the hydraulic feed-off system is as follows: Beginning with the right hydraulic piston (3) in its bottom position and the left hydraulic piston (3) in its top position, as shown in Fig. 3, the pilot valve actuator (4) on the right piston rod is ready to actuate the pilot valve (5), which, in turn, will actuate the master walking feed air control valve (6) that applies air pressure to the right brake and releases the left brake. Rotation of the drum, caused by the tension of the drilling line, also rotates the applied right brake, which raises the right hydraulic cylinder (2) and discharges the hydraulic fluid from the right to the left cylinder (2) through an adjustable choke in the hydraulic line joining the two cylinders. The fluid entering the left cylinder (2) causes the left piston (3) to retract the previously unlocked left brake band. As the left hydraulic piston (3) approaches the bottom position, the pilot valve actuator (4) mounted on the rod actuates the left pilot valve (5), which reverses the walking feed-off air control valve (6), applying air pressure to the left brake air cylinder (1), and releasing pressure in the right brake air cylinder. The upward motion of the left piston (3), caused by the rotation of the applied left brake, forces the fluid in the left cylinder (2) to flow back to the right cylinder through the choke manifold, thereby forcing the right piston (3) down to the starting position. The above cycle of the operation repeats itself as long as the walking feed is in operation and the rate of feed is affected only by the friction of the pistons in their cylinders and the choking of the flow of hydraulic fluid, consisting of water and soluble oil, through the adjustable choke. The main air brakes can be used at will when the control system is set for feed-off and an emergency manual brake is provided with a modified mechanical equalizer. For making round trips the hydraulic pistons are locked in a neutral position by the mechanical equalizer (9) and the braking is actuated only by air cylinders.

The feed-off mechanism is put into operation by applying air pressure to the braking system by the main brake feed-off valve and pressing the feed-off starting button, Fig. 4. The rate of feed is then controlled by the opening of the hydraulic adjustable choke valves (8), Fig. 1.

The walking feed-off air brakes are suitable for feeding drill pipe at a rate of a fraction of an inch per hour to a maximum of 120 ft per hr with eight lines and 100 ft per hr with 10 lines.

Slight leakage of the fluid in the hydraulic system of the feed-off mechanism is automatically replaced from the drilling rig water system through an automatic charging device that is connected directly to the brake rim cooling water system. In addition, the hydraulic system is provided with a safety control that automatically applies the air brakes in

FIG. 7. Diagram of remote weight indicator pick-up.

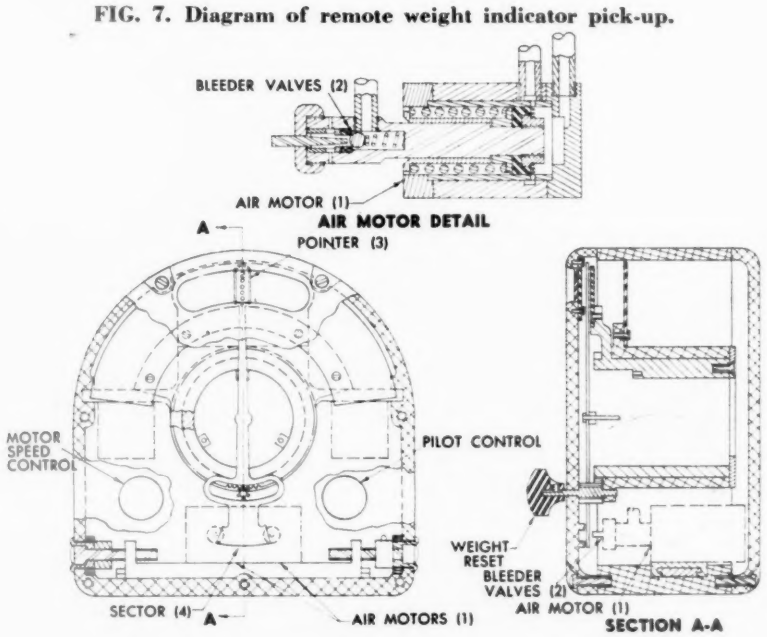
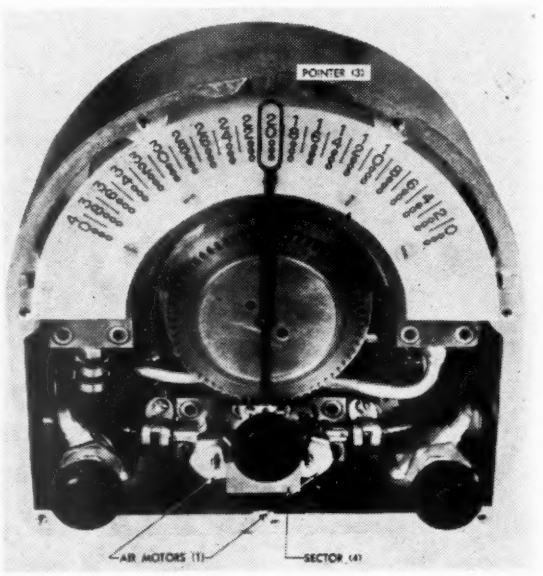


FIG. 8. Remote weight indicator pick-up.



Merry Christmas
AND BEST WISHES
OF THE SEASON
AMERICAN
AMERICAN ROLLER BEARING CO.
416-420 MELWOOD AVE., PITTSBURGH 13, PA.

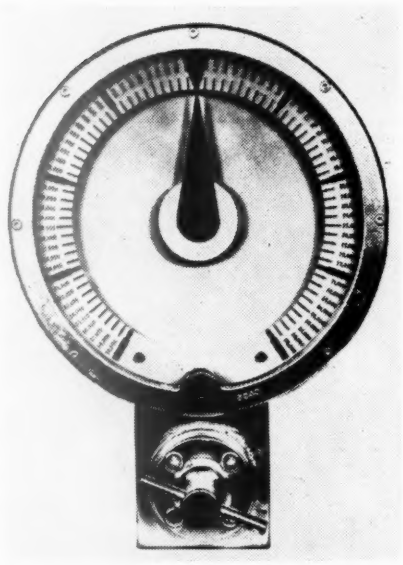


FIG. 9. Net weight on bit weight indicator.

the case of failure of the hydraulic system. The entire walking feed-off mechanism and air braking system becomes a part of the standard drawworks, eliminating the necessity of handling an additional truck load of feed-control equipment.

Three sets of these brakes are currently in operation in Texas. The first set was installed in March, 1946, and has been used to drill eight holes amounting to a total of approximately 81,000 ft of hole. The second set has been in service one year and has been used to drill approximately 41,000 ft of hole in addition to working over four 10,000-ft wells. The third set was recently installed on a drawworks in operation on a well drilling below 12,000 ft and was used for completing that hole to a total depth of 14,629 ft.

● **Automatic control apparatus.** Apparatus for the automatic control of feed-off of drill pipe with the walking feed-off air brakes, or other feed control mechanisms, has been developed. To date this equipment has been used to control automatically drilling with the walking feed-off air brakes described above. The automatic control mechanism provides means for (1) actuating the hydraulic feed-off orifice valves on a hydraulic feeding device, (2) taking weight shown on the weight indicator to control the automatic feed-off mechanism, (3) automatically stopping feed-off when weight on the drill bit reaches a maximum predetermined amount, and (4) automatically shifting the automatic control from weight to drill pipe torque when the torque reaches a predetermined value.

This equipment consists essentially of air-driven valve-actuating mechanisms whose events are timed and controlled by a weight indicator take-off and steam engine manifold pressure that is proportional to torque developed by the engine.

● **Orifice valve actuator.** Referring to drawing Fig. 5 and photograph Fig. 6, the hydraulic feed-off orifice valve actuator consists of two air-operated motors, two pawls, and one rotating device suitable for coupling directly to an orifice valve in the hydraulic feed-off system. The air motors are spring-actuated, air-returned, with adjustable strokes.

● **Remote weight indicator pick-up.** The weight indicator pick-up device is essentially a remote reading weight indicating mechanism. This apparatus, shown in drawing Fig. 7 and photograph Fig. 8, consists of a pair of very slow speed air-actuated spring-returned motors (1), the events of which are controlled by a common master valve and stroking alternately like the adjacent pistons of any conventional two-cylinder double-acting reciprocating steam engine, employ bleeder valve (2) connected to the piston rods so that impingement of the rod ends opens the bleeders and, in turn, exhausts the previously mentioned hydraulic orifice valve actuator motors, causing them to rotate the hydraulic valve turning ratchet.

The remote indicating mechanism is in reality an indicating controller action. In addition to the pair of air motors containing the bleeder valves in the rod ends, this station consists of a dial that can be set for any value between zero and 40,000 lb weight on bit. The commercial dead line net weight on bit weight indicator, Fig. 9, used in conjunction with this equipment, controls the remote indicator by Autoflight transmitters. So long as the net weight on bit indicated on the dead line weight indicator agrees with that set on the remote station, the pointer (3), Fig. 7, remains in a vertical position. When the pointer on the net weight on bit indicator registers other than the chosen net weight, the pointer on the remote station also moves in the same direction from the vertical. A sector (4) attached to the lower position of the pointer moves into the space between the bleeder valve plunger (2) and the indicator case causing impinge-

FIG. 10. Automatic drilling control mechanism mounted on drawworks.

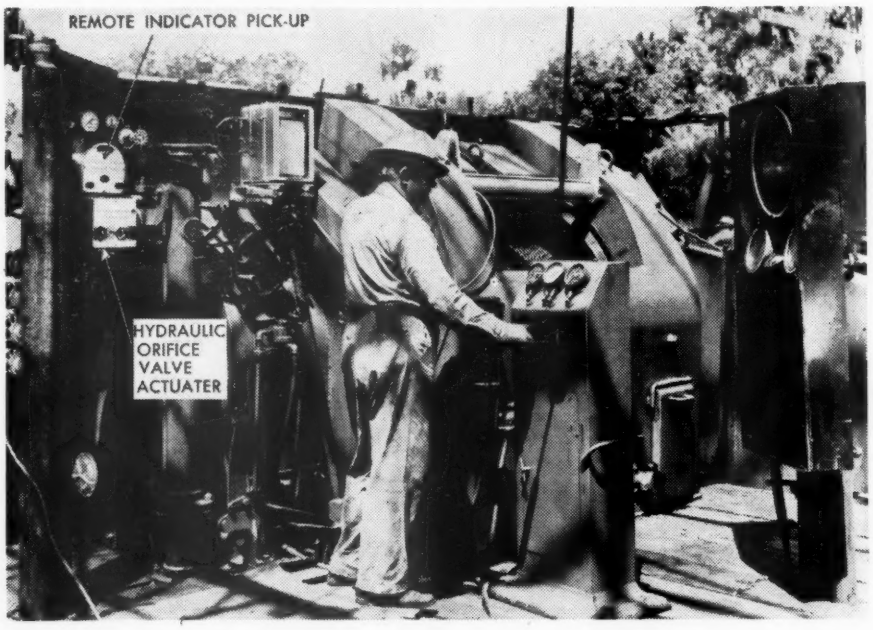
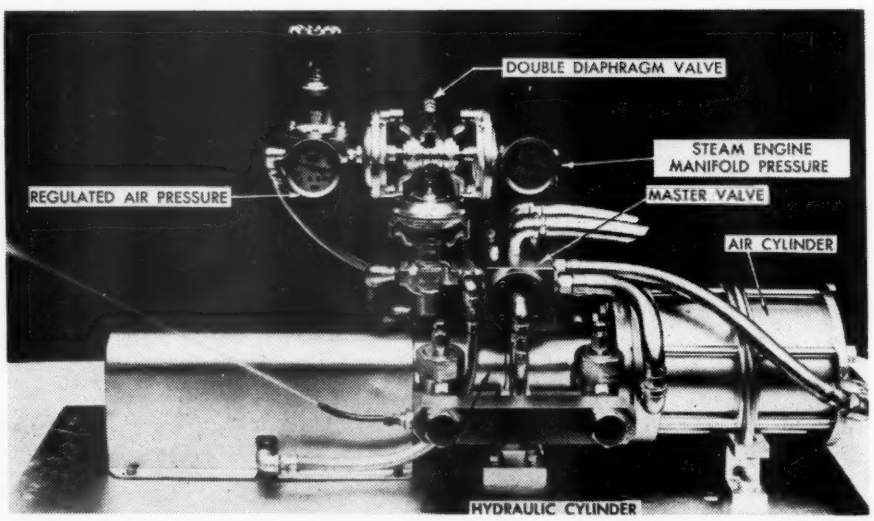


FIG. 11. Air-driven hydraulic pump.



90% OF ALL V-BELT DRIVE PROBLEMS SOLVED ECONOMICALLY WITH TEXROPE

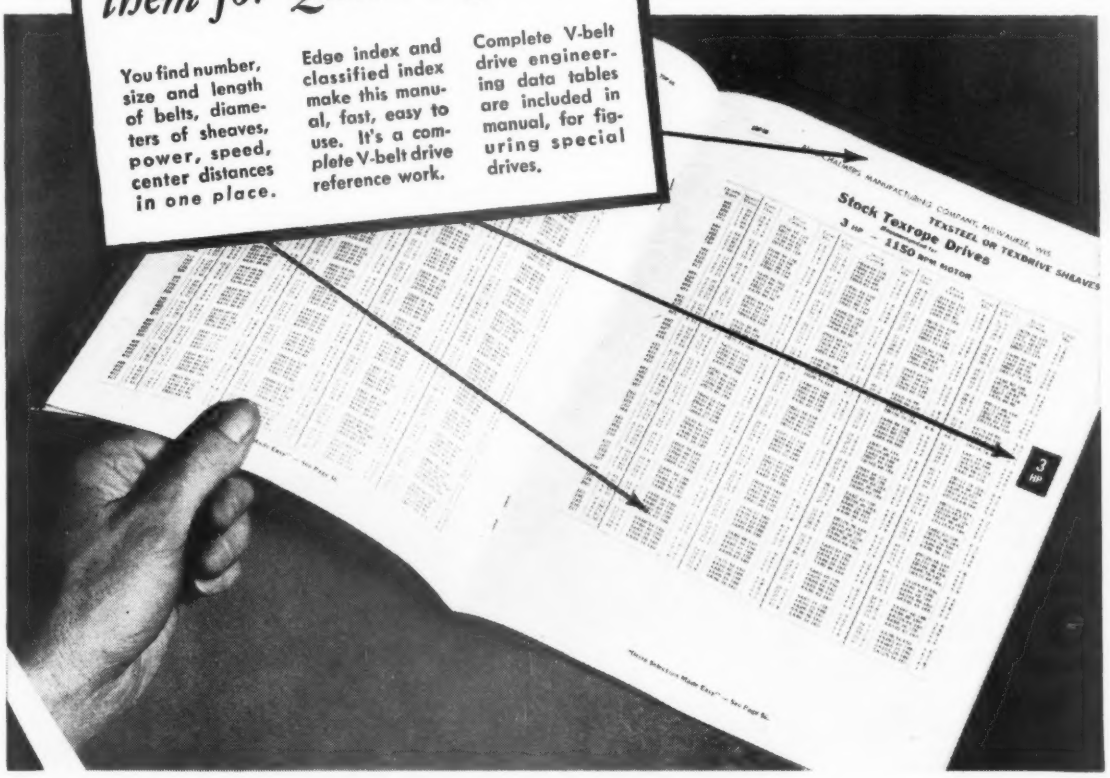
Pre-Engineered Drives

This New Manual Lists them for Quick Reference

You find number, size and length of belts, diameters of sheaves, power, speed, center distances in one place.

Edge index and classified index make this manual, fast, easy to use. It's a complete V-belt drive reference work.

Complete V-belt drive engineering data tables are included in manual, for figuring special drives.



USING STOCK BELTS AND SHEAVES, Texrope engineers have selected the *best* drive for each requirement . . . the drive most economical in first cost and in maintenance.

Only Allis-Chalmers offers you this complete Pre-Engineered drive manual. It is the product of 23 years of industrial V-belt drive experience, the finest engineering talent in the business.

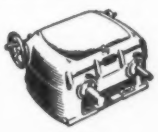
Here is a book that will save you time and money in the purchase of V-belt drive equipment. Copies have been sent to many Texrope users and dealers. If you don't have a copy yet, write for Texbook No. 20P40. ALLIS-CHALMERS, MILWAUKEE 1, WIS. A 2335

TEXROPE ..Greatest Name in V-Belt Drives

"Super 7" V-BELTS
Five Types — Sizes to suit every power transmission job.

Texsteel, Texdrive, "Magic-Grip"
— sheaves in a full range of sizes, grooves.

"Vari-Pitch" SHEAVES
Exact variations in speed, stationery or motion control.



SPEED CHANGERS
Speed variations up to 375% at the turn of a crank.

ENGINEERING
Finest V-Belt engineering talent in the world—at your call.

TEXROPE "Super 7" V-Belts result from the cooperative research of two great companies — Allis-Chalmers and B. F. Goodrich. They are sold only by A-C.

Texrope, Super-7, Texsteel, Texdrive, Magic-Grip and Vari-Pitch are Allis-Chalmers Trademarks

ALLIS-CHALMERS

One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products

1847 1947 A CENTURY OF SERVICE to Industry THAT MADE America Great

ment of the bleeder valve stems mounted on the air motor piston rods, bleeding air from one of the hydraulic valve actuating motors previously described. The actuator makes a corrective adjustment and, if the sector remains in the way during subsequent strokes, makes additional adjustments until the weight is corrected to that selected by the operator. The interrupted adjustments controllable both as to frequency and magnitude are the features that prevent "hunting," which would result from the use of any continuous influence. The response to a single adjustment of the hydraulic orifice valve is often so slow that the corrective adjustment, if made continuously, is overdone before it becomes evident that it is having any influence. Fig. 10 shows the hydraulic orifice valve actuator and remote indicator pick-up mechanisms mounted on the hydraulic manifold attached to the drawworks equipped with walking feed-off air brakes.

● **Excess weight control.** Excess weight on bit is prevented by a pair of quick-closing diaphragm-operated valves in the hydraulic lines, which stop the feed-off if the rate of feed cannot be reduced rapidly enough by the air motor closing the hydraulic orifice valve. The quick-closing valves operate after a predetermined number of strokes have been made by the air motor actuator and arrest the feed-off until the excess weight has been drilled off and the hydraulic control valve has been closed sufficiently to regulate the rate of feed to maintain the desired weight on the bit. This feature was incorporated for the purpose of handling the condition that exists after drilling through a soft stratum into a section of very hard formation.

● **Torque control.** The maximum desired drill pipe torque control consists essentially of a double diaphragm valve assembly. An adjusted air pressure is admitted to one of the diaphragms that competes with the drilling engine manifold steam pressure, which is in proportion to the torque developed by the engine. If the steam pressure exceeds the regulated air pressure, the valve controlled by the double diaphragm actuates the same two diaphragm-operated quick-closing hydraulic valves used to prevent excessive weight on the bit. During the torque drill-off operations, the air supply to the air motors in the remote indicating controller station is shut off, thus stopping all attempts to make weight adjustments while the excess torque drill-off is in control.

● **Pick-up apparatus.** Provisions were made in designing the automatic drilling control apparatus to hoist automatically the drill pipe with the walking air brakes when drill pipe torque becomes excessive. It has been interesting to note that while drilling approximately 15,000 ft of hole with the automatic feed control no condition was encountered that required picking up the pipe, indicating that the maximum desired drill pipe torque control is adequate for minimizing drill pipe twist-off hazards.

The automatic walking air brake hoisting equipment can be operated manually by pressing a button. This feature is considered highly desirable for such operations as fishing, milling, or other delicate control of drill pipe and a means to slowly hoist the bit off bottom in case of failure of the drawworks engine or main driving chains. An auxiliary air-driven hydraulic pump capable of developing three hydraulic hp will hoist 10,000 ft of drill pipe with the pick-up apparatus at a rate of approximately 60 ft per hr. Any steam, air, or electrically driven hydraulic pump could be adapted to this application. The air-driven hydraulic pump shown in Fig. 11 was mounted permanently on the drawworks skids equipped with the experimental drilling control apparatus.

All the automatic drilling control apparatus described above except the dead line weight indicator is mounted directly on the drawworks and does not constitute additional equipment that must be disconnected and moved separately. Most of the valves used in connection with the system are standard commercial items.

Field tests of the automatic control equipment used in conjunction with the walking feed-off air brakes indicate that the mechanism can maintain a more uniform weight on bit than with manual control of the hydraulic feed when drilling in either uniform or broken formations and the feed obtained with the automatic control is much more uniform than that obtainable with the conventional mechanical friction brakes. At very slow rates of feed a lag in the signal transmitted from the dead line weight indicator, due principally to fric-

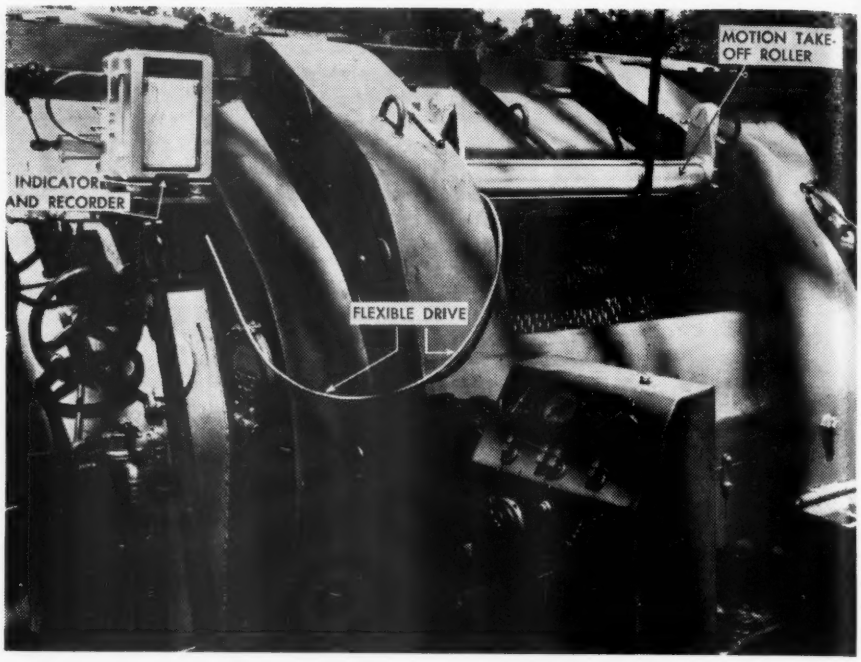
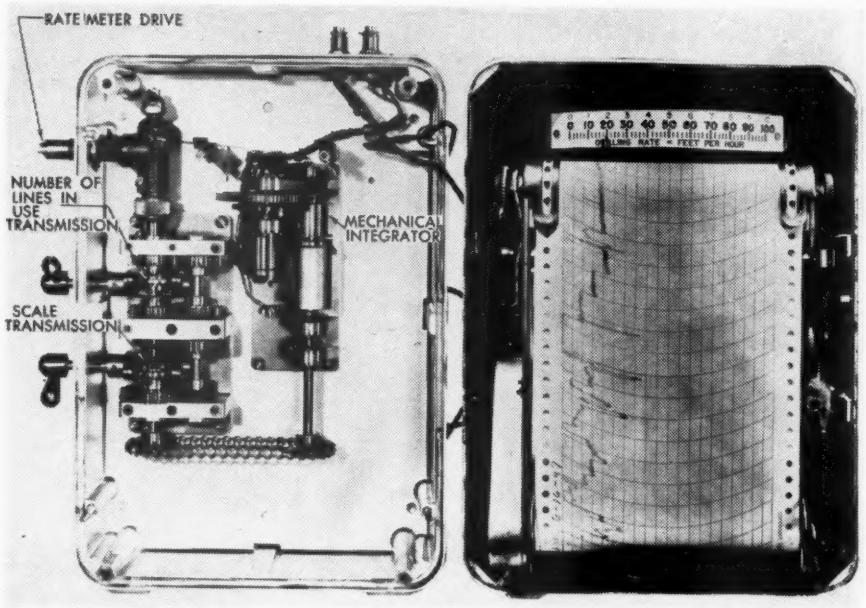


FIG. 12. Rate meter and motion mounted on drawworks.

FIG. 13. Indicating and recording drilling rate meter.



HUNT TOOL COMPANY

FIELD SHOPS: Houston, Bay City, Corpus Christi, Jennings, Harvey
EXPORT SALES: Hunt Export Company, 19 Rector St., New York
Adva. Pte. R. Saena Pena 832, Buenos Aires
Port of Spain, Trinidad.

A BUSINESS BUILT ON SERVICE

tion of the line on the sheaves of the traveling and crown blocks, limits to some extent the ability to maintain constant weight on bit. The same lag in the dead line weight indicator affecting the uniformity of automatic control affects the manual control as much if not more in most cases. Comparative tests made by using the automatic control and manual control when drilling at rates less than 5 ft per hr proved that the automatic control could maintain a more uniform weight on bit.

● **Drilling rate meter.** In order to study more carefully the results obtained with the automatic drilling control and as an accurate means of evaluating automatic drilling control equipment, a continuous indicating and recording rate meter was developed. This meter was designed as a permanent attachment to the drawworks to be actuated from the live line and to be engaged and disengaged automatically when drilling is started and interrupted. The equipment is mounted permanently on the drawworks so that it needs attention only once a week at which period the charts are changed, the ink replenished, if necessary, and the clock wound.

The motion take-off, Fig. 12, consists of a roller having a length equal to the width of the drawworks hoisting drum mounted on a pair of arms that pivots on brackets anchored to the drawworks guard. The roller is automatically forced into engagement with the live line when drilling is started and released when drilling is interrupted. The roller in turn drives through a gear train and flexible shaft to a transmission that is set for the proper number of drilling lines in use and the desired scale on the indicator and recorder. Two scales are provided, one having a range of zero to 10 ft per hr for very slow drilling rates and a second for drilling rates of zero to 100 ft per hr, each having 50 direct readable divisions. The output of the transmission is connected to an electrically operated mechanical integrator. Fig. 13 shows the transmission and integrator, which are mounted in a case containing either a clock-driven or depth scale-driven recorder. When the clock is used for driving the chart, the instrument will plot drilling rate in feet per hour versus drilling time. An additional transmission is provided to permit the instrument to plot drilling rate in feet per hour versus drilling depth. In the latter case, the clock is used to control the integrator only.

The drilling rate meter has been found invaluable in aiding drilling progress when drilling at very slow rates in hard formation. It is also indicated that the use of a drilling rate meter of this type will be of material benefit to geologists in correlating logs. Several months' field service of the drilling rate meter using the spring-wound clock for driving the chart has proved its ability to withstand rig vibration and to obtain an accurate record of drilling rates.

● **Governor for controlling rotary speed.** In order to maintain constant rotary speeds for any chosen condition, the steam engine powering the rig equipped with the automatic drilling control apparatus described above has been provided with a new type flyball throttle governor. For properly controlling rotary speeds, it is desirable to use a governor capable of regulating the rotary speed over a range of 30 to 300 rpm. Most conventional governors are built with spring or weight controls that limit their ability to regulate over a range greater than 4 to 1. In order to provide a 10 to 1 speed control and to permit remote regulation of the governor for controlling the rotary speed, a new type of air-operated centrifugal flyball governor was designed and built for regulating the steam engine throttle valve for maintaining the desired speed with varying loads. Fig. 14 shows the governor mounted on a 14 x 14 steam engine, which is provided with a motion take-off connected to one of the crankshafts. The engine take-off is equipped with an air-operated clutch for engaging the governor when the engine is used for driving the rotary. The governor is provided with an air-loaded piston actuator to effect speed changes. More or less air pressure is applied to the piston actuator thus necessitating either greater or less rotative speed on the part of the rotating pendulum to close or open the engine throttle valve as required. The adjustments not only can be made while the prime mover is in motion, but the increments can also extend over a minimum range of 10 to 1. A commercial loading-unloading regulating air valve, placed at the operator's station, is used to regulate the governor actuator piston air pressure and therefore the governed prime mover speed. At medium and high speeds the governor will perform essentially like a conventional weight-loaded governor whose weight is changed to produce speed changes. At low speeds, as the piston actuator air pressure approaches and becomes equal to zero, the governor will have the characteristics of the original flyball governor.

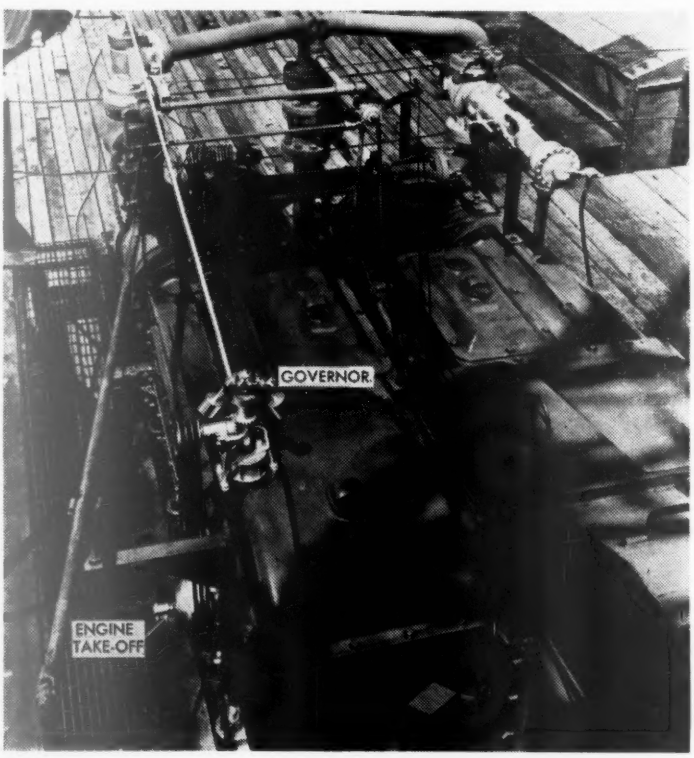


FIG. 14. Air-operated governor on steam drilling engine.

● **Summary and conclusions.** In summary, this development consists of a conventional band-type brake that substitutes hydraulic cylinders for the eye bolts used on drawworks brakes for anchoring the dead end of the band with respect to the drawworks skid. Valves of the air system are synchronized with the movement of the hydraulic pistons to affect a drilling feed-off mechanism that is actuated by pull of the live line on the drum that operates alternately the right and left brake bands when feeding off. This type of feed control mechanism has been used successfully to drill 130,000 ft of hole. Equipment for controlling automatically the feed-off of drill pipe with the walking feed-off air brakes, using the weight indicator as a basis for control, indicates that the mechanism can maintain a more uniform weight on the bit than with manual control of the hydraulic feed and that a much more uniform weight on bit can be maintained with the automatic control than with conventional mechanical friction brakes.

The direct reading and recording drilling rate meter has been found invaluable in aiding drilling progress, especially when drilling at very slow rates in hard formations. It is difficult to compare manual with automatic control of rates of less than 5 ft per hr without the assistance of recorded drilling rates. The rate meter has been of assistance in regulating the automatic control as well as helpful in choosing the desired weight and corresponding rotary speed for any given hard formation when using hand control.

The automatic drilling control mechanism has not been in service long enough at this time to evaluate fully the advantages of this type of equipment from the standpoint of faster drilling speed and lower costs. ★★★

IT'S A MIGHTY FINE FEELING

. . . to have your slush pumps equipped with all MISSION PUMP PARTS!

Everybody likes the long, trouble-free service they get from their slush pumps when they use *all* Mission Pump Parts.

They like it for many reasons. Drilling contractors make more money, drillers make hole faster and everybody has less trouble when their pumps give better service.

Mission Pump Parts are easy to find. They give such good service that they are the favorite of leading operators everywhere. As a result, you can get them at any good supply store.

MISSION PISTON RODS
"Super-surfaced" or "File Hard" types for lowest rod costs under any conditions.

MISSION FLUID END PISTONS
"Change the rubbers and save the piston."
The long life of the rubbers reduces shut-down time. *Replaceable* rubbers reduce piston costs.

MISSION SLUSH PUMP VALVES
"Pull the bushing and save the seat."
Field proved through years of service to make your slush pumps more dependable.

MISSION GLAND PACKINGS
Pressure seal regulates packing tightness for longer packing and rod life.

Sold through supply stores everywhere

Mission MANUFACTURING CO.
HOUSTON, TEXAS

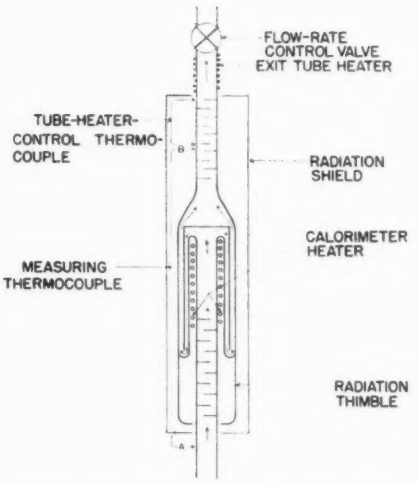
EXPORT OFFICE: 30 Rockefeller Plaza, New York 20, N. Y. EUROPEAN ADDRESS: London, England.

Flow calorimeter measures specific heats of gases

A NEW flow calorimeter for more accurate measurements of the specific heats of gases has been developed by R. B. Scott of the National Bureau of Standards. This apparatus was constructed in connection with a program sponsored jointly by the Bureau and the Office of Rubber Reserve for the determination of the thermodynamic properties of materials involved in the production of synthetic rubber and related substances. The greater precision of the new instrument is chiefly due to the almost complete elimination of heat leaks by various features of design. The small heat capacity of the calorimeter also results in improved accuracy through the easier and more rapid attainment of a constant temperature distribution within the system, for only under conditions of steady temperature is an accurate measurement possible.

Accurate data on specific heats and other thermal properties of gases are of value to chemical industry, where they are used in calculations that predict the results of chemical reactions. With sufficient knowledge of the thermodynamic properties of the compounds involved, it is possible to state the range of temperature within which a given reaction will occur and to estimate closely the relative amounts of the products.

Specific heat is most simply obtained experimentally by adding a measured amount of heat to a fixed mass and recording the temperature rise; however, the heat capacity per unit volume of a gas is so low that small accidental heat leaks are often comparable in size to the heat used in actually raising the temperature of the gas. Reduction of the ratio of heat loss or gain to heat input is thus one of the chief problems of gas calorimetry. In the calorimeter constructed at the National Bureau of Standards, this is accomplished by causing the gas to flow continuously at a uniform rate through an insulated chamber in which it is heated electrically. The heat capacity is then calculated from the heat input, the temperature rise of the gas, and the rate of flow. With gas calorimeters of this general type, a correction is usually made for heat leaks by making measurements at varying flow rates and extrapolating the apparent specific heats to infinite rate of flow, where such errors are negligible. In the new apparatus, however, special precautions have reduced heat leaks to such an extent that a correction for them is unnecessary. This advantage greatly lessens the number of necessary observations and also makes the results more trustworthy, for there are errors in calorimetric measurements that increase with increasing flow rate and cannot be removed by extrapolation to infinite flow.



Schematic diagram of the new flow calorimeter. Entering the calorimeter at the bottom, the gas flows upward through the central calorimeter tube of monel metal past a series of baffles. The rise in temperature of the gas is indicated by the *measuring thermocouple*. After it has been raised, the gas passes upward again past a series of baffles and out through the *flow-rate control valve*. The *exit tube heater* serves to establish a zero temperature gradient in the upper part of the tube, thus reducing heat transfer along the tube. The entire apparatus, except for the flow-rate control valve, is enclosed in a highly evacuated metal case (not shown) immersed in a constant-temperature bath. Before entering the calorimeter, the gas flows through a helical coil, in which it is brought to the temperature of the bath.

The entire calorimeter is immersed in a constant-temperature bath. The gas whose specific heat is to be measured enters the system through a copper helix, in which it is brought to the temperature of the bath. It then flows into the calorimeter proper, where it traverses a labyrinth surrounding a constantan heater, and leaves the calorimeter through a throttle valve. The temperature rise within the calorimeter is determined by appropriately placed thermocouple junctions.

A uniform rate of gas flow is obtained by maintaining a constant pressure on the inlet side of the calorimeter and a constant lower pressure at the outlet. Adjustment of the throttle valve in the outlet tube then provides the desired rate of flow, which is determined by weighing the gas collected in a condensing reservoir within a given time.

In the construction of the calorimeter, resistance to flow was reduced as much as possible, so that gases having low vapor pressures could be passed through the system at satisfactory rates. As it was necessary to measure the specific heats of vapors that corrode copper and silver, all parts traversed by the gas were made of monel metal.

Heat leaks to or from the interior of the calorimeter are minimized in several ways. Conduction along the inlet and outlet tubes is reduced through the use of tubing of monel, a poor-conducting metal, having a wall thickness of 0.01 in. Radiation along the tubes is prevented by a series of baffles, which in addition promote thermal equilibrium between the gas and the tube walls. Heat leaks due to either conduction or radiation are also lessened by providing a long section of tubing between the inlet and the heater, and by heating the outlet to the final temperature of the gas. Radiation to or from the inner portion of the calorimeter is prevented by a copper radiation shield kept at the temperature of the inner adjacent calorimeter wall by means of an electric heater. The necessary adjustments in the power to the heater are made in accordance with the readings of a three-junction thermocouple.

The accuracy of the apparatus was checked by measuring the specific heat of oxygen[1], which had previously been accurately calculated at the Bureau from the latest spectroscopic data for this gas. The experimental valves obtained at minus 30 C, 40 C, and 90 C differed from the spectroscopic valves by 0.06, 0.00, and 0.10 per cent, respectively. From a consideration of the data for oxygen, the probable error of the specific heats obtained with this calorimeter is estimated as 0.07 per cent.

The new calorimeter has been used at the Bureau by Ruth K. Cheney, Jane W. Mellors, R. B. Scott, and P. F. Wacker to determine the specific heats from minus 30 to 90 C of isobutane, isobutylene, 1-butene, *cis*-2-butene, butadiene, styrene, and ethylbenzene.[1,2] Isobutane is a principal raw material for the production of aviation gasoline and is also converted to isobutene—a substance used in large quantities for the preparation of butyl rubber and isobutanol. 1-Butene, like the 2-butenes, is converted to butadiene, the major component of GR-S rubber. A knowledge of the thermodynamic properties of these materials is expected to aid in the more efficient operation of plants in which they are produced or used.

1. Paul F. Wacker, Ruth K. Cheney, and Russel B. Scott, "Heat Capacities of Gaseous Oxygen, Isobutane, and 1-Butene From Minus 30 C to Plus 90 C," *J. Research NBS* 38, 651 (1947) RP 1804.
2. Russel B. Scott and Jane W. Mellors, "Specific Heats of Gaseous 1, 3-Butadiene, Isobutene, Styrene, and Ethylbenzene," *J. Research NBS* 34, 243 (1945) RP 1640.

★ ★ ★

A HOLIDAY WISH

May you succeed this year in recapturing the Christmas spirit of your boyhood—its eagerness, its excitement, its genuineness. This is the sincere holiday wish of Gaso, its executives and employees and its distributors throughout the oil country.

Corrosion of oil well equipment*

By L. C. CASE, Gulf Oil Corporation

● **Abstract.** Corrosion of oil well equipment has probably received less attention and is less well understood than many other corrosion problems, although some effective remedies are now known. In general, well equipment corrosion is due to water and where the corrosion is severe the water has certain recognizable characteristics. It is shown also that water-oil ratio is significant, depending on the nature of the oil and water. Resistant materials are limited by cost. Likewise, coatings are usually uneconomical due to cost and short life. Chemical neutralization is not highly successful. Formaldehyde has indicated a high degree of effectiveness in sulphide areas and wetting agents give promise of development.

● **Introduction.** The corrosion of oil well subsurface equipment, and subsequent failures due to corrosion, constitutes a major economic and technical problem. Usually, the costs involved first come to the attention of company management and then all technical personnel may have immediate cause for concern. Logically, most corrosion problems should be approached from both standpoints, for chemists and engineers are known to be poor economists.

In general, the corrosion of metals has many causes and some effective remedies. In particular, the corrosion of oil well equipment apparently has a number of causes that are relatively well understood but effective and economical remedies are disappointingly few. This apparent paradox should be considered in view of the modifying factors, attendant to well operation, over which there is no control or the control measures constitute unsound economics.

The causes of corrosion are usually more easily determined with surface equipment and the success of control measures may be predicted with a much greater degree of certainty. Likewise, the regulation of anti-corrosion treatment is relatively simple with surface equipment and results may be evaluated in a much shorter period. Thus it may be said that the existing condition of enormous annual cost to the industry due to well equipment corrosion and the relatively few satisfactory solutions to subsurface corrosion are no doubt due, in some measure, to complexity of the problem and lack of control over physical and chemical forces that are present in oil well operation. The existing condition is also due to relative newness of the problem, or the fact that only in recent years have technicians really given the problem their undivided attention and showed a tendency toward the pooling of information in solution of a common problem. Corrosion problems are almost as old as the use of metals. Systematic investigations have revealed a wealth of information and a great many established rules governing the prevention of corrosion in various industries. On the other hand, even while these events were taking place, oil production men considered corrosion to be more or less of a necessary evil and abandoned wells where the costs became excessive. This is still being done, of course, but not without some investigation of costs of possible preventive methods vs. reserves.

The present acceleration of interest and investigations concerning oil well corrosion cannot fail to produce results. Condensate well corrosion may be cited as an outstanding example. Only a few years ago condensate well corrosion was first reported as an amazing phenomenon, and one for which there seemed to be no valid reasons. Today the situation is much improved. Some of the causes of condensate well corrosion are definitely known with the result that effective and economical remedies are now in use. The basic causes and best remedies will doubtless be reduced to established rules as the data accumulate. This result of partial solution has not been achieved without the expenditure of many technical manhours and costly investigations in laboratory and field. In general, however, it may be said that the benefits resulting from condensate well corrosion investigation to date far outweigh the costs of the research and that the benefits will no doubt continue.

The record is not so good concerning pumping wells, which of course produce water. It is unfortunate that these trouble-makers are also generally small oil producers that will thus not merit much remedial cost. Very little material of real value has been published on causes and prevention of corrosion in pumping wells. We know that the very presence of such factors as water and the rod string complicates the system enormously. It is worthy of note that wells pumped by means other than rods do not have tubing corrosion, even in severely corrosive areas. It should be noted also that rod strings are frequently found to be so strongly magnetized, after removal from a well, that a large hammer or similar steel object will adhere to the rod bundle as it hangs in the derrick. This phenomenon indicates the flow of considerable current around the tubing concentric to the rods. It is only logical to assume that such flow of current has much to do with tubing corrosion and this corrosion could be greatly reduced, or even stopped entirely, by elimination of the rod string. One other method would be to stop the travel of current. Unfortunately, there is no known method at present for accomplishing this result. The flow of current into a well may be prevented by the use of insulating flanges; however, there seems to be nothing to do about the flow of current within a pumping well. Insert type pump failures may result from relatively little corrosion where the corrosion products collect to cause clogging or excessive wear. Slight pitting on rods under load produces fatigue cracks and resulting rod breaks. The more costly tubing failures are usually due to relatively more corrosion, mainly on the tubing interior.

Although much remains to be done concerning pumping well corrosion, it may be that we have sufficient information to set forth a few rules concerning corrosion in given areas.

1. The corrosion is due to water.
2. Where the corrosion is severe, the water has certain general characteristics.
3. Severe corrosion takes place simul-

TABLE 1. Subsurface costs and production data. Annual per well production and operating expense due to corrosion.

Field or state	Seminole, Okla.	Kansas	New Mexico*	Illinois	Michigan
No. wells tabulated	235	76	347	300	16†
Water, bbl	55,484	107,600	8,258	20,457	16,904
	(85.1%)	(93.1%)	(18.3%)	(72.6%)	(80.2%)
Oil, bbl	9,722	8,030	36,739	7,720	4,190
	(14.9%)	(6.9%)	(81.7%)	(27.4%)	(19.8%)
Tubing expense	117	689	7.20	32.90	0
Rod expense	175	361	0.51	109.90	16
Miscellaneous subsurface expense	351	55	26.40	140.10	85‡
Total subsurface expense	643	1,105	34.11	282.90	101

*$49,311.00 ($142 per well per yr) expense for flowing and gas lift is not included. The major portion of this was due to paraffin trouble.
†Four representative wells from each of four pools.
‡Pump and paraffin expense.

*Presented before The American Society of Mechanical Engineers, Houston, Texas, October 5-8, 1947.

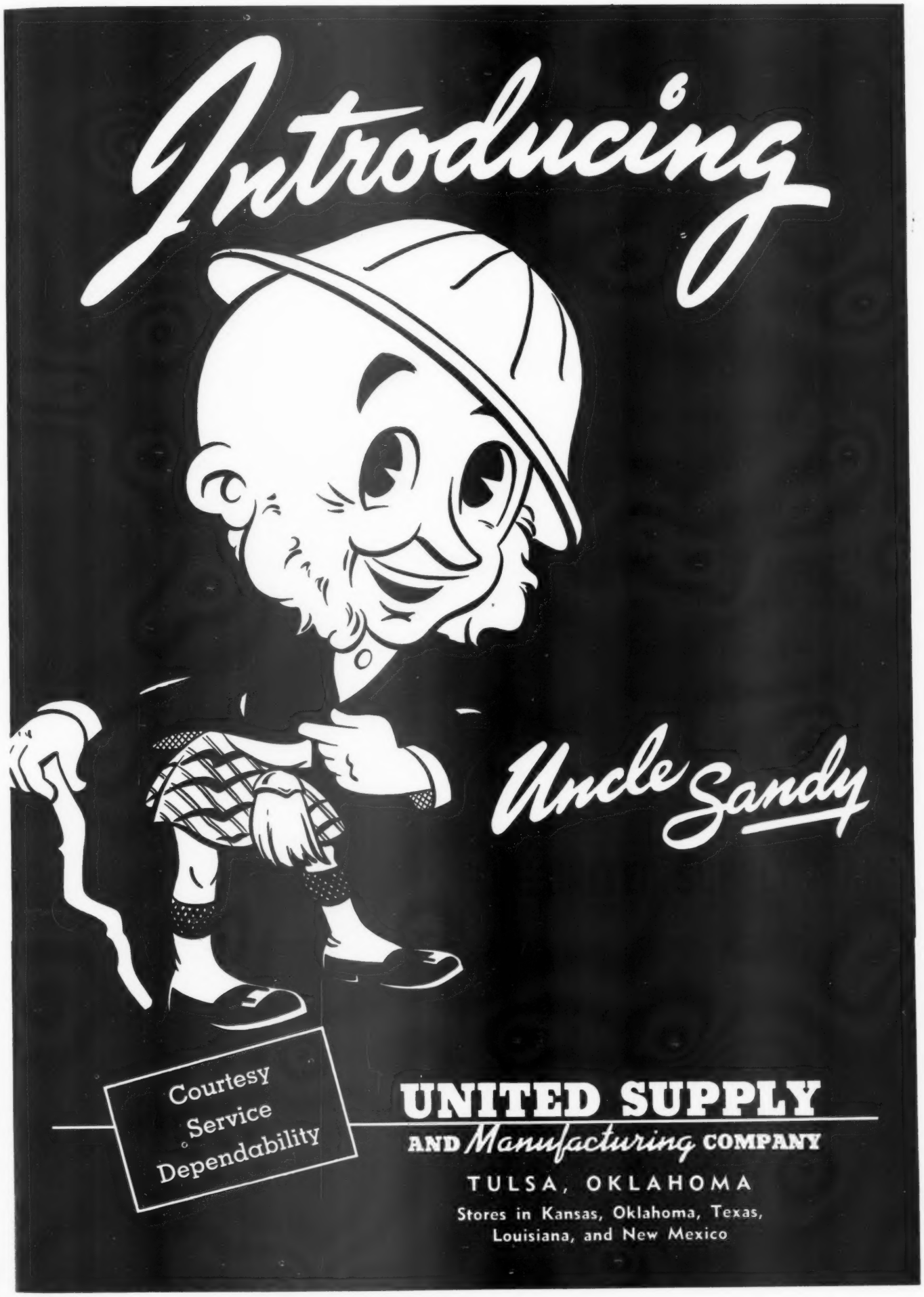

Introducing
Uncle Sandy
Courtesy
Service
Dependability
UNITED SUPPLY
AND Manufacturing COMPANY
TULSA, OKLAHOMA
Stores in Kansas, Oklahoma, Texas,
Louisiana, and New Mexico

TABLE 2. Comparison of corrosive and non-corrosive areas. Well per year data.

Field or state	St. Louis, Oklahoma	Western Kansas	Seminole, Oklahoma	St. James, Illinois
No. wells tabulated	8	76	15*	14
Classification	Corrosive	Corrosive	Non-Corrosive	Corrosive ?
Water	262,184 (92.8%)	167,600 (93.1%)	133,000 (93.5%)	19,360 (78%)
Oil	20,497 (7.2%)	8,030 (6.9%)	9,300 (6.5%)	5,470 (22%)
Tubing expense	363	689	88	39
Rod expense	1,150	361	356	63.60
Miscellaneous subsurface expense	484	55	15	204
Total subsurface expense	1,997	1,105	459	306.60

*Selected for similarity in fluid production to Kansas wells.

TABLE 3. Comparison of brines produced in corrosive and non-corrosive areas.

	St. Louis, Oklahoma	Seminole pool, Oklahoma	Chase pool, Kansas	Hobbs pool, New Mexico	Centralia, Illinois	St. James, Illinois
Per cent water	92.8 Corrosive	85.1 Non-corrosive	93.1 Corrosive	18.3 Non-corrosive	72.6 Non-corrosive	78.0 Corrosive ?
Na	5,283	51,848	8,388	2,845	34,750	30,156
Ca	361	9,136	1,391	483	3,494	1,625
Mg	162	1,721	396	180	1,440	902
SO_4	200	556	1,792	2,000	nil	390
Cl	8,740	100,706	14,818	3,070	63,900	51,520
HCO_3	634	79	701	2,098	109	392
Total solids	15,380	164,046	27,486	10,676	103,693	84,985
Specific gravity	1.013	1.112	1.021	1.011	1.074	1.062
pH	7.2	6.8	6.4*	7.7	6.8	5.7-7.1
H_2S	Present	nil	Present	Much	nil	Slight

*Determined at well.

taneously with water increase, to a rather definite ratio, depending on characteristics of oil and water.

These rules are few and simple but they allow certain predictions that are helpful in any area where the nature of the water is known and where future water-oil ratios may be forecast with reasonable accuracy.

● **Comparison of costs and conditions in various areas.** A comparison of subsurface equipment expense for various areas is given in Table 1. This comparison shows only western Kansas to be generally corrosive. It will be noted also that the most important item in Kansas is the tubing costs.

There are a few "hot spots," or strongly corrosive areas within districts, which do not exhibit excessive overall equipment costs. Probably the most notable of these is the group of eight wells in the St. Louis pool, Oklahoma. Table 2 compares Kansas with groups of wells in three other districts. A comparison of conditions in St. Louis, Oklahoma, with those in Kansas is of considerable interest. It will be noted that the percentages in fluid production are closely similar, but there is relatively less tubing expense and more rod and pump expense in the St. Louis wells. Depth of wells is approximately equal. The much larger volume of water produced at St. Louis seems to be a fairly logical explanation. Several wells in the St. James pool, Illinois, are understood to be giving some trouble from corrosion. This might be predicted from the nature of the water and the per cent water produced.

The comparison of 15 non-corrosive wells from Seminole, Oklahoma, with 76 Kansas wells merits some consideration. The percentages of fluid production per well are very closely similar. The Seminole wells actually produced more fluid per well, and from approximately 1000 ft deeper, than the Kansas wells. The Seminole wells, however, had very little tubing and pump expense. Rod expense was closely similar but the Seminole rod expense was evidently due to heavier loads rather than to corrosion.

A comparison of the brines produced in various districts is given in Table 3. It will be noted that H_2S occurs in the corrosive areas but that all H_2S areas are not necessarily corrosive. Both theory and practice strongly indicate that other factors are equally important. Amounts of water produced and percentage of water must be taken into consideration. Conceivably, the percentage of water at which corrosion became severe should be modified appreciably by characteristics of both oil and water, and of course the depth of pumping. These modifications actually seem to be in effect when characteristics are compared in the various brines. On the basis of H_2S content, the water from New Mexico should be the most corrosive of all; however, this water seems to be "buffered" at a relatively high pH value by the large amount of calcium bicarbonate present. Similarly, the brine from the St. James pool, Illinois, should be rather strongly corrosive, even though it contains only a small amount of H_2S. Such indications are obtained, not very accurately, from the pH values. Only one of these values was obtained in the field and it is believed that all would be appreciably lower if they had been obtained in such manner, for example, loss of CO_2 and H_2S causes the Kansas brine to have a pH well above "7", after it has been open to the air for a few hours.

● **Tubing and rod corrosion, western Kansas.** The corrosion process, which takes place on both rods and tubing, consists of the formation of an iron sulphide film, followed by failure of the film and its repeated formation. Tubing failure occurs most frequently at points of contact of boxes with tubing interior. Although this is somewhat erroneously termed "rod cutting," the actual process is well understood in the field. Pitting frequently takes place, outside the rod-worn areas, and sometimes proceeds through the tubing as fast as the corrosion-wear process. It is believed that pitting is possibly accelerated by galvanic action where the pipe surface remains continually water wet. In contrast, a piece of pipe steel suspended in an asbestos waste salt water disposal line was found to be protected by a coating of FeS, after one month exposure, so that very little corrosion was taking place. The same test in a steel line results in continued pitting. Entry of air greatly accelerates the process, as evidenced in various salt water disposal operations. The possibility of air entry into the pumping wells has finally been satisfactorily disproved. Observations as early as 1936 indicated that air entered the casingheads for only a very short distance, as evidenced by rust on a few top joints of tubing exterior only. More recently, closing of casingheads on a one-year test failed to produce any reduction of corrosion on tubing interior. As oil in the annulus contains H_2S, the reaction of excess H_2S with oxygen to form water and free sulphur would apparently preclude the possibility of oxygen reaching the bottom of a well. This reaction goes to completion in a few hours. Recent field tests, using liquid oil-soluble tracer, introduced in small amounts in the annulus, showed that many days are required for the tracer to enter the produced fluid. The data on this field test are stated in Table 4. A gas in the casinghead would obviously have even less tendency than an oil-soluble liquid to circulate downward.

It seems remarkable that tubing and rod corrosion are not even worse when we consider that FeS-coated surfaces are

TABLE 4. Time required to obtain returns on oil-soluble tracer*

Days	Oil, bbl	Days	Oil, bb
1	22	14	6
2	12	15	8
3	12	16	Rec. T.
4	10	17	8
5	10	18	12
6	10	19	10
7	12	20	15
8	10	21	9
9	12	22	14
10	12	23	14
11	16	24	24
12	5	25	17†
13	10	26	9†

*15 gal CCl_4, mixed with 15 gal crude, added to annulus.
†Tracer showed up.

Well data:
Operating fluid level, 790 ft.
Distance from operating level to tbg. perf., 2482 ft.
Calculated oil in annulus, 2236 gal.
Water production, 520 bbl/day, 24-hr cycle.
Oil-soluble chemical added, 4.5 gal/day.

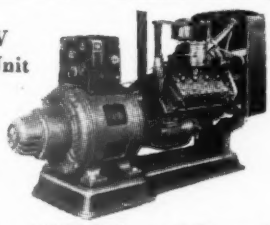
KRW INDUSTRIAL POWER PLANTS

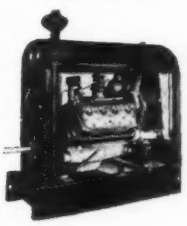
CUT COSTS 40-50% ... THIS NEW BOOK GIVES ALL FACTS ABOUT THESE FAMOUS LOW COST FORD-POWERED, EASILY SERVICED UNITS ... THOUSANDS IN DAILY USE

Write for it today!

CUT POWER OR PUMPING COSTS IN HALF WITH
KRW
SINCE 1916
A MARK OF DEPENDABILITY
KRW INDUSTRIAL POWER UNITS
DEPENDABLE ECONOMICAL FORD POWER
KRW UNITS operate on GASOLINE, NATURAL GAS, BOTTLED GAS
OPERATING COSTS PER HOUR
ELECTRIC MOTOR 80% EFFICIENCY Cost Per Kilowatt
KRW INDUSTRIAL UNIT OPERATING ON NATURAL GAS Cost Per 1000 Cu. Ft. 1125 B.T.U.
KRW INDUSTRIAL UNIT OPERATING ON GASOLINE Cost Per Gallon (Tax Free)
STUDY THIS CHART IN TERMS OF YOUR NEEDS . . . FEUL AVAILABILITY AND FEUL COSTS. THEN NOTE THE SAVINGS THAT KRW DELIVERS . . .
KRW units pay for themselves quickly
THE 100-H.P. FORD V-8

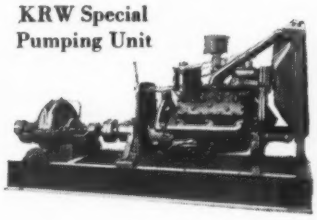
KRW 20KV Generating Unit





KRW Industrial Power Unit (enclosed type)

KRW Special Pumping Unit



● **Powered by the famous Ford V-8—100 H. P. Truck Engine, KRW Industrial Power Units operate on Gasoline (tax free), Natural Gas or Butane. Their maintenance and repair cost is held at a minimum because of around-the-corner and world-wide, low-cost Ford service and the Ford Engine and Parts Exchange Plan. Mail the coupon for this informative book today.**

K. R. WILSON

BUFFALO 3, NEW YORK

29

K. R. WILSON, 215 Main St., Buffalo 3, N. Y.

Please send me a copy of the new KRW Industrial Power Unit Book.

Name .....

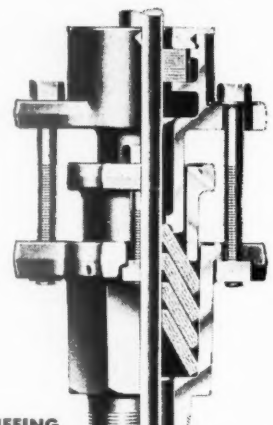
Address .....

City and Zone ..... *State* .....

CONE PACKING
CAN STAND THE PRESSURE

Hercules' exclusive Cone Packing has successfully withstood more than 2,000 pounds pressure. Cone Packing practically eliminates friction . . . will not burn out if well pumps-off. The need for wabblers is eliminated. No foreign lubrication is required. But most important to YOU, Hercules Cone Packing will outlast old-style ordinary packing many times . . . is easy to install and is moderately priced!

Sold at all supply stores.



Also made with Tee Base.

HERCULES
TOOL COMPANY
TULSA, OKLAHOMA, Box 286
EXPORT OFFICE: 30 Rockefeller Plaza
NEW YORK, U.S.A.
CABLE ADDRESS: HERTOCO

TABLE 5. Kansas Arbuckle wells. Per cent water production at start of severe corrosion.

Pool	Well	Per cent	Pool	Well	Per cent
Cress	A	88	Kraft	A	91
Chase	A	93	Kraft	B	75
Chase	B	82	Silica	A	89
Chase	C	90	Silica	B	88
Chase	D	85	Silica	C	92
Chase	E	88	Silica	D	88
Eldorado	A	90	Silica	E	75
Gurney	A	70	Silica	F	88
Walter	A	86	Silica	G	85
Sharpe	A	79	Silica	H	82
Sharpe	B	85	Silica	I	75
Sharpe	C	80	Silica	J	95
Sharpe	D	93	Silica	K	80
Stottenberg	A	90	Silica	L	80
Stottenberg	B	85	Silica	M	80
Stottenberg	C	80	Silica	N	91
Wilkins	A	80	Silica	O	80
Wilkins	B	88	Silica	P	95
Wilkins	C	75	Silica	Q	95
Wilkins	D	95	Silica	R	90
Voshell	A	87	Silica	S	86
Sullivan	A	93	Silica	T	93
Burrton	A	75	Silica	U	90
S. Silica	A	90	Silica	V	86

Average 85.7 per cent.

actually more easily water wetted than steel surfaces. If the FeS film is in contact with oil most of the time, then it may not become water wetted. The inherent ability of the oil, or lack of such ability, to wet the steel surfaces must have a great deal to do with corrosion rates. Kennedy and Rogers[1] have shown that the Kansas oil has little wetting ability. Better wetting ability of the New Mexico oil, coupled with less water production and water that is better "buffered," seems to offer a satisfactory explanation for present lack of corrosion in New Mexico. It is believed, however, that trouble may be predicted for certain New Mexico wells when the water content of fluid increases and they are pumped with rods. This statement is based on records of a few West Texas wells where conditions are similar.

Table 5 illustrates water percentage at the start of corrosion in 48 Kansas wells. The maximum deviation from the average of 85 per cent water is shown to be 15 per cent and the average deviation 5.5 per cent. There are many exceptions to the predictions for Kansas wells that may be based on this tabulation; however, the data are useful in a general way in anticipating corrosion trouble.

● **Anti-corrosion methods.** *Resistant materials, alloys, and coatings.* Early efforts at corrosion prevention consisted of searching for resistant materials. This method has several limitations, the most important one being that of cost. For example, we know that nickel-plated rods and tubing would withstand H_2S corrosion almost indefinitely, but the cost is too high for all but very large producers. Subsurface equipment has been designed largely from the standpoint of strength and steels that are strong and resistant to wear are often quite susceptible to corrosion. Furthermore, dissimilar metals in motion in the presence of electrolyte are common causes of accelerated corrosion. Field tests have shown definitely that we cannot pump with rods through cement-lined tubing. It was found that rod-wear and other failure of the cement lining caused fouling of pumps and resulting stripping jobs. Plastic coated tubing does not offer much promise to date where it is necessary to use rods. Improved coatings and methods of application apparently offer considerable promise for the future where rods are not used. At present, however, field tests show generally that the average life of the coatings on oil-well tubing does not justify the expense of application of the several coats necessary.

Chemical methods. It has been shown that severe corrosion is due to one or more of the following causes: Excessive water, H_2S, low pH, and lack of wetting ability of oil. Chemical treatment should therefore logically attempt the correction of these conditions. It should be noted that water shut-off is a separate and distinct engineering problem. Thus when the engineer asks why corrosion problems have not been solved, the chemist may counter with the question "why produce so much water?"

If we must accept the condition of producing high percentages of corrosive water, then corrective treatment may be outlined essentially as follows:

1. Neutralization, or caustic to react with H_2S and to raise pH value.
2. Precipitation agents to form protective coating. Alkaline compounds to form protective deposit of $CaCO_3$, $BaCl_2$ to form coating, etc.
3. Oil wetting agents to increase wetting ability of oil.
4. Addition agents—to react with H_2S, forming films more easily wet by oil. Formaldehyde is best example.

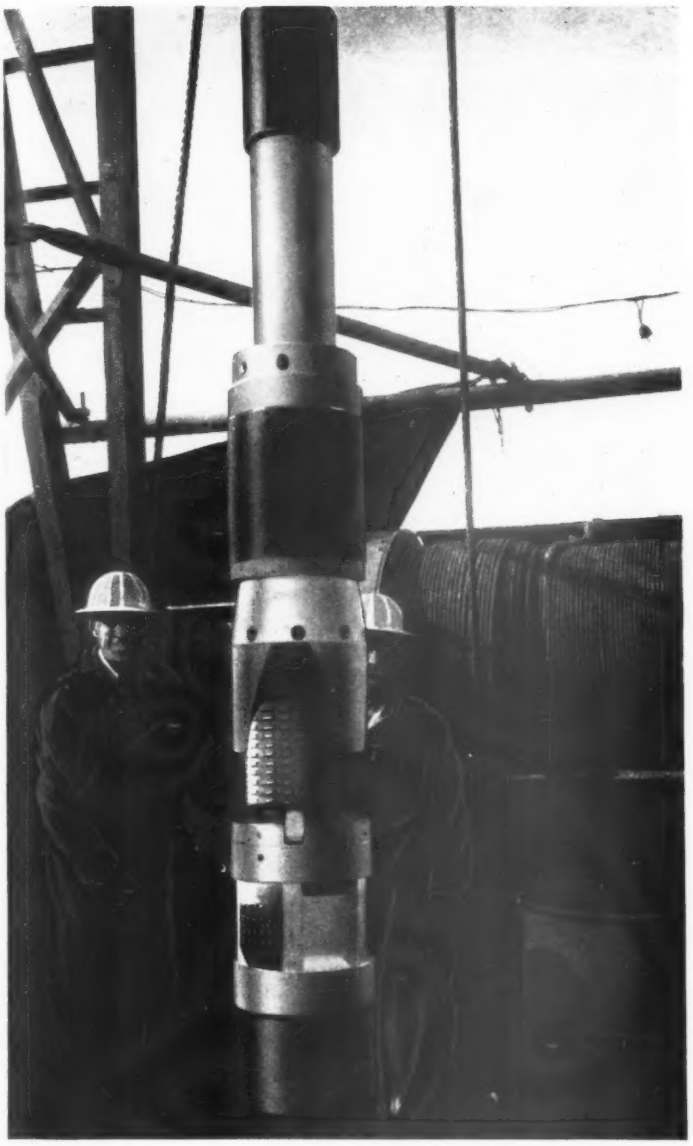
Neutralization has not been found sufficiently effective to merit costs of treating. This is due to the fact that excessive scale and pump trouble result long before neutralization is accomplished. Likewise, deliberate deposition of material from the oil well brine by addition agents was found to be of no benefit because the deposit is always excessive near the pump and too thin or absent entirely farther up the well

The last two methods appear to offer considerable promise. As of December, 1946, one major oil company was treating 203 wells in Kansas with formaldehyde. Another important operator was treating 30 wells that had been on test for 13 months. None of these 30 Kansas wells had experienced a second failure of rods or tubing whereas, before treatment, the same wells had failures within four months after new installation and frequent failures thereafter. One operator reports a field test on seven wells, where subsurface costs were tabulated 98 well-months before treatment with

[1] H. T. Kennedy and W. F. Rogers, personal communication.

☆ ☆ ☆

The latest test of the Spring Hill oil field, on the southern shore of the Magellan Straits in Chile, South America, is reported to have come in with a production rate estimated at 600 to 700 bbl a day from a depth of 6900 ft. This is the ninth well drilled in the area. Two other tests have yielded oil in commercial quantities.



Completing Another Well With a WILSON *"Positive Seal"* HOOK WALL PACKER

Yes—the Wilson "Positive Seal" Hook Wall Packer is making friends throughout the Industry—because it gets the job done, even under adverse conditions.

Due to the patented design of the expander cone, this Packer will withstand the extremely high differential pressures usually encountered in Dual Completion Wells.

The non-vulcanizing pack-off element is expanded by conical wedge—and does not depend on excessive tubing weight on Packer to secure pack-off. The split pack-off gives a "lip-seal" which means that the higher the pressure from below—the tighter the seal.

In the Wilson "Positive Seal" Hook Wall Packer, three friction blocks, hard faced with stellite, are used in place of friction wiper springs. These friction blocks are held against the wall of casing by three rugged coil springs—and insure correct setting regardless of depth.

In any specified pipe size one packing element fits all weights of pipe. This feature means small inventories, also, more important, Packer can be set in "mixed" strings of casing.

Contact your nearest Wilson Supply Store or write.

WILSON SUPPLY COMPANY

1412 MAURY ST., HOUSTON, TEXAS

SALES OFFICES: Tulsa, Oklahoma; Dallas and San Antonio, Texas. LOS ANGELES: Western Pressure Control, 5700 Santa Fe Avenue. TRINIDAD, B.W.I.: Neal Massey Eng. Corp.

BRANCH STORES: TEXAS: Kilgore, Beaumont, Barbers Hill, Bay City, Monahans, Alice, Victoria, Corpus Christi, Columbus. LOUISIANA—Lake Charles, New Iberia, Harvey, Shreveport. ARKANSAS—Magnolia. MISSISSIPPI—Natchez.

formaldehyde and 91 well-months after treatment. Average subsurface costs were $220 per well-month prior to treatment and $84 after treatment. Further, this operator reports that there have been no failures at all on new equipment when formaldehyde treatment was started immediately after installation. Formerly, failures followed new tubing and rod replacement within four to five months. The formaldehyde treatment is also being tried in the eight corrosive wells in the St. Louis pool, Oklahoma, where rod trouble is prevalent. Results will not be indicated for several months, or until a period of several normal rod jobs has elapsed. It is understood that results with formaldehyde in West Texas fields have been variable. Results on two wells in Andrews County, Texas, were not satisfactory. The treatment is said to indicate some benefit at one well in the Goldsmith pool. According to Paul Menaul, of the Stanolind Oil and Gas Company, who used formaldehyde extensively, the conditions are quite variable in West Texas and New Mexico oil fields. Hydrogen sulphide is said to range from 100 mgm/l. to 600 or more in the brine. Also, the brine may have pH of slightly above neutrality to about 6.2 when tested at the wellhead. It is Menaul's opinion that where H_2S is high and the pH below neutral, corrosion will be severe when water content of fluid becomes appreciable. Table 6 illustrates some possibly related data concerning the formaldehyde method. Formaldehyde placed in a well is usually quite insufficient to react with all H_2S in produced brine and seldom shows any marked effect on H_2S content as the brine is produced at the surface. In this case, however, the H_2S content of well effluent varied from 10 to 31 mgm per liter, being lowest when formaldehyde was high and vice versa. The data do not appear to be sufficiently accurate, or in sufficient detail, to allow charting.

TABLE 6. Tests for formaldehyde in well effluent.

First day		Second day	
Time sampled	Formaldehyde, mgm/l.	Time sampled	Formaldehyde, mgm/l.
9:30 a.m.	300	8:50 a.m.	6
11:25 a.m.	80	11:00 a.m.	60
1:30 p.m.	50	1:25 p.m.	6
4:00 p.m.	30	3:50 p.m.	10

Well data:

Treatment: 9 qt 25 per cent formaldehyde in annulus at 7:50 a.m. each day.
Pump: 2 in., 23 x 44 spm, 24 hr 460 bbl at 100 per cent eff.)
Production: 30 bbl oil, 376 water per day
Tubing: 2½ in. Capacity less displacement, 16.5 bbl.
Casing: 5½ in. Fluid in annulus 600 ft.
Water: pH 6.9, H_2S 10-31 mgm/l.

Oil wetting agents appear to offer considerable promise for prevention of H_2S corrosion of well equipment. One oil-soluble wetting agent has been on test in four Kansas wells for more than a year and has been found second only to formaldehyde. A new oil-soluble compound developed by a well-known manufacturer of oil treating agents is stated to be showing favorable results in three field tests in West Texas. Doubtless other oil wetting agents will be developed as investigation is continued. The problem with the oil wetting agents seems to be primarily that of finding the ones that will work in sour oil and, second but equally important, finding a method for testing so that the best compound may be isolated without time-consuming field tests. If this can be accomplished, it seems quite possible that oil wetting agents may prove even more efficient and more economical than formaldehyde.

● **Summary.** It has been shown that severe corrosion occurs only where appreciable water is produced and where the water has certain general characteristics. The percentage water produced may be used as a guide to predict the occurrence of severe corrosion if other conditions are equal. The per cent water produced at the start of severe corrosion is modified by wetting ability of the oil and the nature of the water. It is strongly indicated that small amounts of H_2S, in water of pH below neutrality, may cause severe corrosion. Conversely, large amounts of H_2S are shown to be relatively non-corrosive where the water is neutral or above. In view of existing data, the best method that has so far been thoroughly tested for combatting H_2S corrosion in Kansas pumping wells seems to be that of formaldehyde treatment. Oil wetting agents give considerable promise but await further development. ★★★

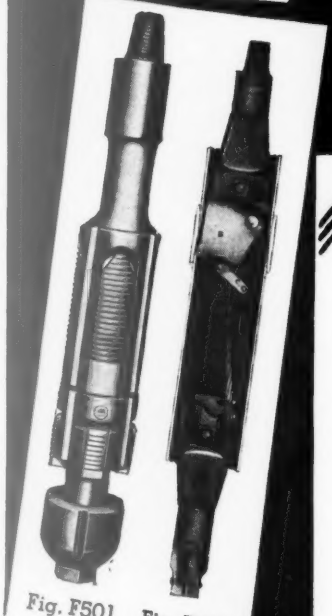


Fig. F501 Fig. F515

SPANG
TRIP SPEAR
(Fig. F501)
REVERSIBLE RIPPER
(Fig. F515)

FOR CASING FISHING JOBS Spang offers a variety of tools including Casing Cutter; Casing Splitter; Out of Collar Ripper (F515); Swage; Bell Socket; Bull Dog Spear; and Trip Spear (F501).

All are made of the best materials obtainable and carefully designed for the work for which they are intended.

For the best in Cable Tools,
SPECIFY SPANG

THE HIGHER STANDARD

SPANG & CO.
BUTLER, PA.

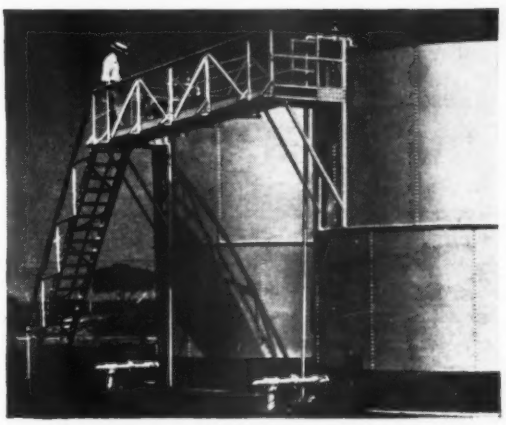
YOUR DEALER SELLS SPANG TOOLS

BS & B BOLTED TANKS

THAT'S fact, not theory. Black, Sivalls & Bryson Bolted Steel Tanks have outlasted many a lease. Torn down, moved, and reset many times, they are still in use . . . 15 . . . 20 years old and still ruggedly resisting corrosion, evaporation, seepage.

The reason for this record is evident in every part, down to the smallest bolt. Responsible workmanship. Field-proven developments. Revolutionary BS&B Thief Valves, unequalled for tightness. Hot Dipping after galvanizing assures an unbroken 4 ounce coating. All lapped seams sealed by 1½" strips of pre-punched, leakproof gasket. Sturdy, simple in design, they're built for long life.

Your nearest BS&B Sales Engineer can help you choose the right type of tank. Trained erection crews are stationed near you, no matter how remote your lease. Write today for copy of new manual on The Choosing and Using of Tanks. Address all inquiries to Oil Field Equipment Division, Executive Officers, Black, Sivalls & Bryson, Power and Light Building, Kansas City 6, Missouri.



BS&B Engineers Periodically check Bolted Tank installations . . . another BS&B service to you.

FOREIGN INQUIRIES INVITED

EFFICIENCY

Cable Address: BLACK, KANSAS CITY, U.S.A.

BLACK, SIVALLS & BRYSON, INC.

RELIABILITY

KANSAS CITY, MO.
CASPER, WYO.
OKLAHOMA CITY, OKLA.
CALGARY, ALTA.

New thermometric standard

A NEW thermometric standard utilizing the freezing point of benzoic acid as a fixed temperature has been developed and made available to industrial and other laboratories by the National Bureau of Standards. The acid, which is specially purified for the purpose, is contained in a cylindrical chamber, about 12 in. long and 2 in. in diam., provided with a thermometer well. This device, known as a benzoic acid cell, affords a means of calibrating platinum resistance thermometers and thermocouples at a temperature near 100 C more rapidly and conveniently and, under certain conditions, more accurately than is possible with the boiling point of water. The temperature provided by the cell is virtually the triple point of benzoic acid (122.362 C).

The boiling point of water is well established as a fixed point in thermometry not only for historical reasons but also because the thermal properties of water and its ease of purification make it an almost ideal standard substance. The laborious barometric measurements required for accurate observations of the steam point have constituted the principal drawback to the use of this temperature in thermometer calibration. Recently, however, as the result of an investigation of the properties of benzoic acid by F. W. Schwab and Edward Wichers of the Bureau, it has been found possible to use the freezing temperature of benzoic acid for this purpose with a precision comparable to that of the steam point as observed in most standardizing laboratories.

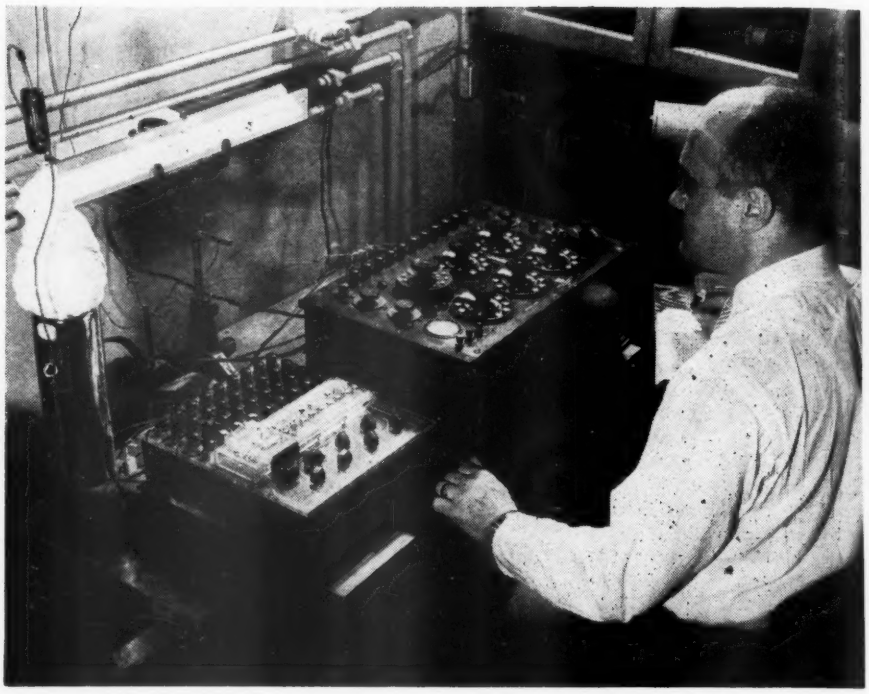
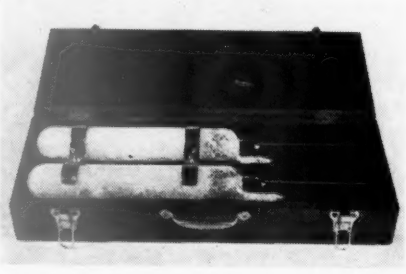


FIG. 2. Calibration of a platinum resistance thermometer using as a fixed point the temperature within a benzoic acid cell. After warming in an oven, the cell, consisting of a thermometer well surrounded by a chamber containing dry benzoic acid, has been placed in the Dewar flash at left, where the acid is gradually freezing. The thermometer to be calibrated, the top of which projects from the flask, is thus maintained at virtually the triple point of benzoic acid 122.362 ± 0.003 C) while its electrical resistance is being accurately measured on a Mueller bridge.

FIG. 1. Benzoic acid cells, developed by the National Bureau of Standards to provide a new thermometric standard for the calibration of resistance thermometers and thermocouples, are now being supplied to industrial and other laboratories. Each cell consists of a thermometer well (its extension visible at right) surrounded by a chamber containing benzoic acid, which is melted and then allowed to freeze gradually. The freezing temperature of one of the cells certified by the Bureau to an accuracy of ± 0.003 C, affords a fixed point near 122 C. An uncalibrated companion cell containing acid of lower purity is useful for practice in manipulation and for pre-warming a Dewar flask in which the certified cell is placed to retard freezing.



To use the cell, it is heated in an oven until the acid has melted and reached a temperature a few degrees above its freezing point. The cell is then shaken until the liquid begins to freeze, forming a mush of fine crystals; thereupon the cell is put in a Dewar flask to retard the rate of freezing. The resistance (or thermocouple) to be calibrated is placed in the well, and observations of resistance (or emf) are made for a period of one to two hours. After the first 30 minutes, the temperature of the cell is constant within 0.001 C for an hour or longer and is reproduced in repeated "freezes" within a maximum range of 0.002 C.

The freezing temperature of each cell issued by the Bureau is certified to an accuracy of ± 0.003C; however, this is an estimate of the uncertainty involved in fixing the temperature on the International Temperance Scale, and does not relate to the constancy with which the temperature is maintained in a given cell during the time necessary for observations or to the day-by-day reproducibility of the cell.

Certified cells[1] may be obtained from the National Bureau of Standards for a fee of $100 each. An uncalibrated companion cell containing acid of lower purity is offered for $15; it is useful for

*More detailed information about these cells can be obtained from the Bureau. Observations on the pertinent properties of benzoic acid are given in "The Freezing Temperature of Benzoic Acid as a Fixed Point in Thermometry," by Frank W. Schwab and Edward Wichers, *J. Research NBS 34*, 332 (1945), RP 1647. This paper has an appendix by Frank W. Schwab and E. R. Smith, which gives a convenient method of calculating temperatures from observations of the resistance of platinum thermometers. Reprint of the paper, with its appendix, are available from the Superintendent of Documents, Washington 25, D. C., at a cost of 10 cents.

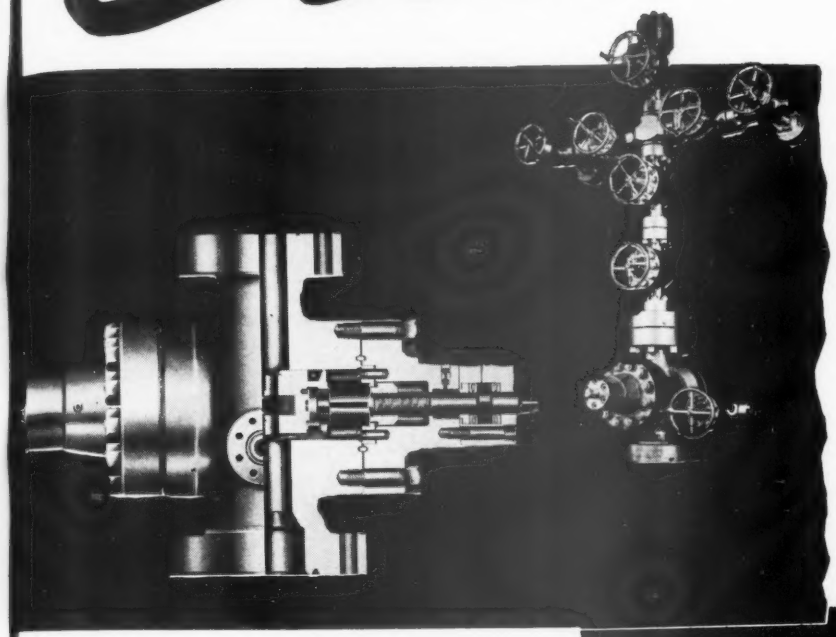
LOCK-SCREW TYPE

RAM TYPE

Cameron

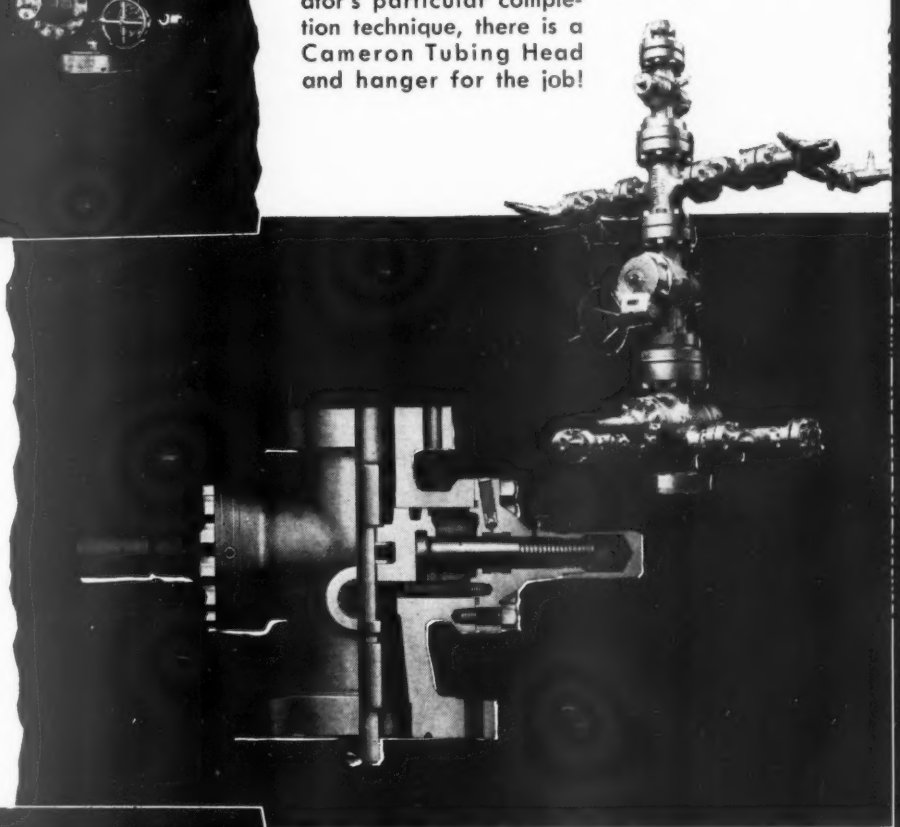
OFFERS BOTH STYLES OF TUBING HEADS with *Eight* types of TUBING SUSPENSION

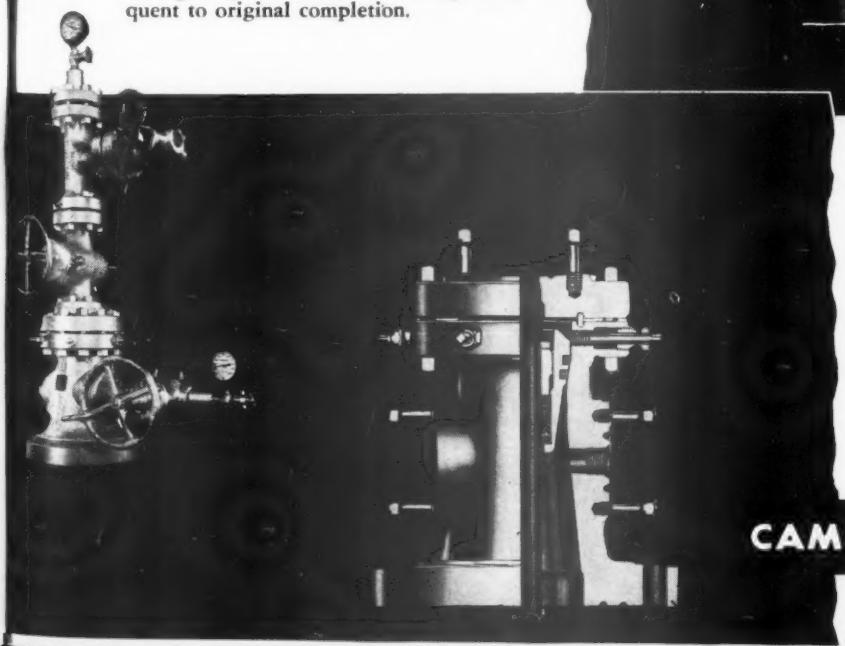
To the Cameron line of Ram Type Tubing Heads, which for many years has been one, if not the, most popular tubing heads in the field, has been added the popular lock screw type head with several proven interchangeable hangers. Now, regardless of subsurface conditions or the operator's particular completion technique, there is a Cameron Tubing Head and hanger for the job!



Above—This is the Cameron Ram-Type Tubing Head that has distinguished itself on most of the industry's record-breaking deep, high-pressure wells. In most instances, tubing is suspended from a hanger flange installed above the head, and its rams are utilized to seal the annulus. (Other uses for the rams are outlined below).

Right—This is the Cameron Ram-Type Tubing Head that is probably used by more production men than any other make. Its rams suspend and seal the tubing string, utilizing a hanger nipple as shown (tubing may also be suspended from hanger flange above the head). This head provides an extra blowout preventer during completion operations and greatly facilitates reworking subsequent to original completion.





Left—This is the new Cameron Type "F" Forged Steel Tubing Head which employs the popular lock screw design. Its flanged housing is an integral alloy forging from the big Cameron 5000-ton press. Several types of tubing hangers are interchangeable in this head, permitting the selection of the suspension and seal most suitable for the completion requirements. The popular Type "FS" "polished joint" Hanger is illustrated.

CAMERON IRON WORKS, INC.

P. O. BOX 1212, HOUSTON, TEXAS

FORGED STEEL UNIONS

Your Most Dependable Servants

Petro UNION

America's most universally used Union! A partial list of proven services: Pressures from a vacuum to 3000 lbs. Temperatures from 100° below zero F. to 1000° above zero F. Steam, Gas, Air, Oil, Gasoline, Ammonia, Chemicals, and all service in which Steel or Wrought Iron Pipe is used. Made to A.A.R. Standards and priced in line with 300 lb. A.A.R. Malleable Iron Unions.

Write for Pamphlet AM-67

SIZES
⅛" to 3"

Socket Weld UNION

This is our "PETRO UNION" with the end pieces reamed to U.S. Navy Specification B-173 for socket welding. Ends squared to facilitate welding. It has permanently lubricated nut threads and machined and cold rolled steel seats.

Write for Pamphlet AM-67.

SIZES
¼" to 3"

Handle-Bar UNION

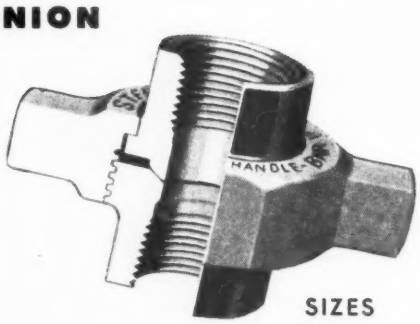
4000 AND 6000 TEST

4000 Test: Sizes ⅜" to 1½" V-thread in nut.

4000 and 6000 Test: Sizes 2" to 4" modified Acme Threads in nut.

Steel to steel, or bronze to bronze cold rolled seats. Permanently lubricated nut threads. To tighten, or loosen the nut, USE A HAMMER INSTEAD OF A WRENCH.

Write for pamphlet 4P-HB.



SIZES
⅜" to 4"

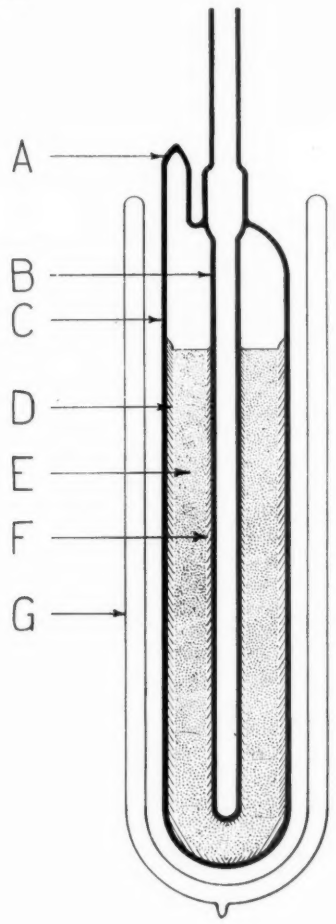
ORDER BY TRADE NAME FROM YOUR JOBBER

ORIGINATORS AND PIONEERS OF FORGED STEEL UNIONS

CLAYTON MARK & COMPANY

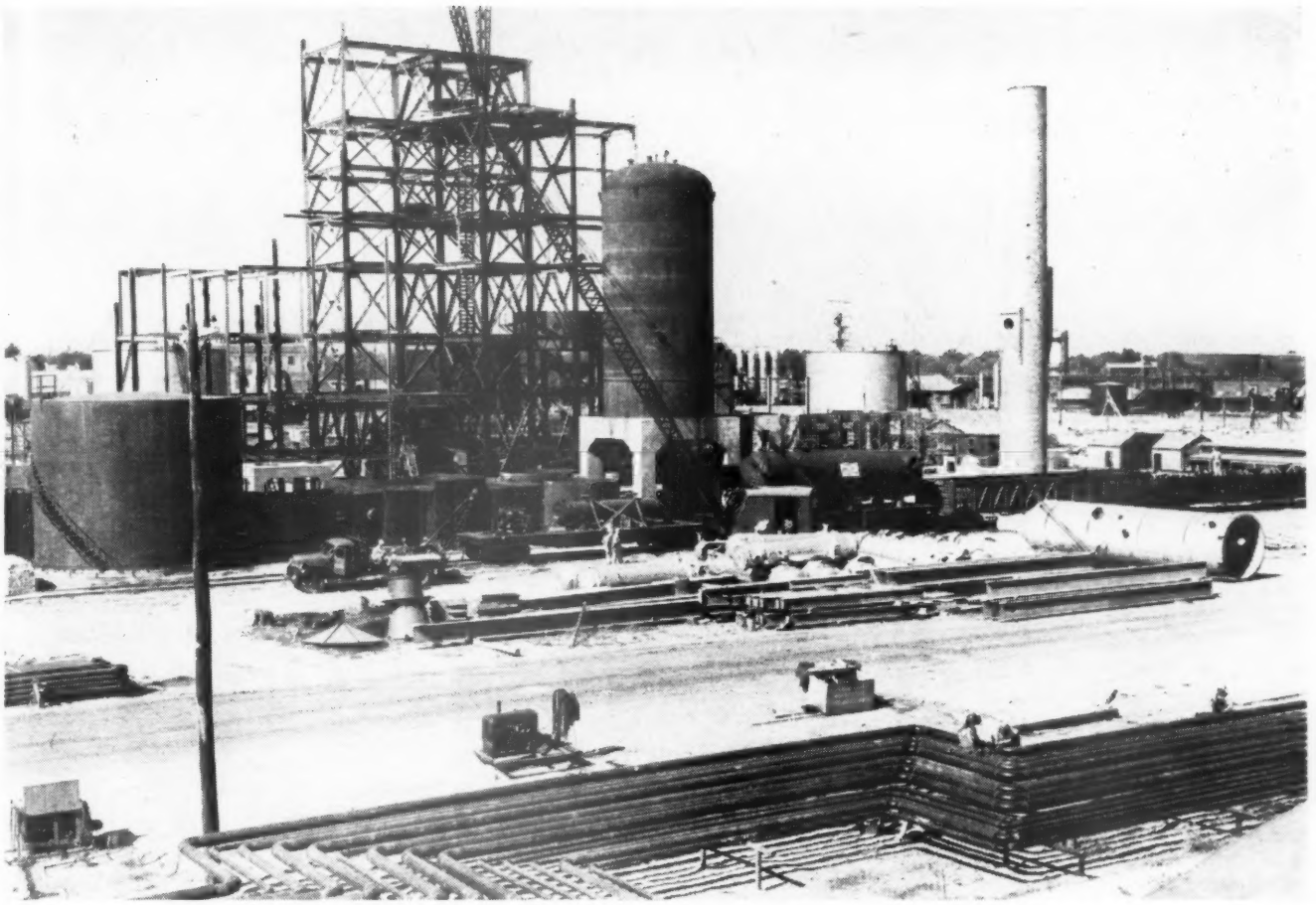
1900 DEMPSTER STREET • EVANSTON, ILLINOIS

FIG. 3. Diagram of the new benzoic acid fixed-point cell, which the National Bureau of Standards is making available to industrial and other laboratories as a thermometric standard for the calibration of platinum resistance thermometers and thermocouples. The cell (C) is first warmed to melt the benzoic acid it contains, and then cooled until a mass of fine needle-like crystals (E) appears throughout the liquid. At this point the cell is placed in the Dewar flask (G) to retard further freezing. When the instrument to be calibrated is put in the thermometer well (B), the slight loss of heat to the instrument causes a very thin layer of acid (F) to freeze on the outer wall of the well. The temperature of the thermometer is thus very nearly the temperature of liquid-solid equilibrium for benzoic acid. As freezing gradually proceeds, a layer (D) of solid benzoic acid forms on the inner wall of the cell. The acid was initially transferred to the cell through the side tube (A), which was then sealed off.



practice in manipulation and for prewarming of the Dewar flask. Cells are available with thermometer wells in three diameters, 8, 10, and 12 mm. The diameter that most nearly fits the instrument to be calibrated should be used.

★★★



Catalytic cracking unit showing main structure and service lines to tank farm in foreground.

Ohio launches refinery expansion program

By R. E. LUTON, *Manager*, Refining Division, The Ohio Oil Company

THE OHIO OIL COMPANY, which is celebrating its sixtieth year of successful operation, recently inaugurated a program of expansion and improvement that will greatly increase the present capacity of its principal refinery at Robinson, Illinois. This program will include the installation of the newest type of fluid catalytic cracking unit.

The refinery now operates on Illinois crude and has a rated capacity of 15,000 bbl a day. A constantly increasing demand for the company's products necessitated the installation of additional facilities. Present processes include atmospheric and vacuum crude distillation, thermal cracking and reforming, gas recovery, and UOP catalytic polymerization. Blending and packaging of lubricating oils are also carried out. Products are gasoline, kerosine, diesel fuel, distillate and residual fuel oils, road oils, and asphalts.

Universal Oil Products Company will design and engineer the new units. The general contractor is Arthur G. McKee and Company. J. F. Pritchard and Company is constructing some of the offsite utilities, such as the water supply system, interconnecting piping, and power lines.

The new facilities will include a two-stage crude distillation unit of special design, a fluid catalytic cracking unit, a gas recovery plant, a UOP catalytic polymerization unit, and a treating plant for gasoline.

● **Latest design in crude unit.** The general design and equipment used on the crude distillation plant represent the newest developments. The unit is designed for a capacity of 27,500 bbl of Illinois crude a day and includes facilities for atmospheric distillation, vacuum distillation, and oxidizing, or airblowing, of asphalt. The crude oil will pass through a desalting unit before entering the atmospheric column.

The following fractions may be taken off the atmospheric side:

	Bbl/stream day
300 F EP stabilized straight run gasoline	4400
300-400 F EP naphtha	3575
500-530 F EP kerosine	2750
625 F diesel fuel	2750
Gas oil	2750

The light straight-run gasoline end point may be varied from 250 to 350 F and that of the naphtha from 400 to 450 F.

Bottoms from the atmospheric side will be pumped into the vacuum column, where the following cuts may be taken off:

	Bbl/stream day
Vacuum gas oil	7370
Penetration asphalt	3130

The bottoms from the vacuum column may be used as flux or road oil, or they may be passed through the continuous oxidizer to produce asphalt of any desired penetration test, according to market requirements. Continuous oxidation of asphalt is employed because a cleaner and more economical operation is there-

by realized. To guard against corrosion, the top section of the atmospheric column is lined with Monel; the remainder of this column, the entire gasoline fractionating column, and the vacuum column are lined with 11-13 per cent chrome alloy.

● **New fluid catalytic cracker.** A new fluid catalytic cracking unit, embodying the UOP features of advanced design, will process Illinois gas oil either on a high conversion recycle basis of 7500 bbl per stream day of charging stock or on a moderate conversion once-through basis of 12,400 bbl per stream day of charging stock. Either natural catalysts or synthetic catalysts of the ground or microspherical type may be used.

In this improved design, placing the regenerator below the reactor permits reducing the size of the regenerator for a given capacity, marked reduction in length and diameter of catalyst transfer lines, dense phase catalyst transfer from the reactor to the regenerator, and a short regeneration air line to the regenerator. The catalyst recovery system consists of three stages of cyclones on the regenerator. The electrical precipitator used on earlier units for the recovery of catalyst fines is omitted.

The reactor design includes dense phase horizontal grids, in addition to the main distribution grid, for reducing catalyst recycling in order to prevent further cracking of cracked products, and to insure maximum gasoline recovery. Internal and external strippers are provided in the reactor for two-stage spent catalyst stripping. The reactor, external stripper, and main fractionating column are protected from the action of corrosive stocks by use of 11-13 per cent chrome alloy steel vessel lining.

Auxiliary equipment for the catalytic cracking unit includes a pressured slurry settler, fired charge heater, steam superheater for the high pressure steam from the flue gas steam generator and the main fractionator steam generators, gas-engine-driven gas compressors, condensing turbo-blower, and special provision for minimizing erosion of the pressure control valve on the regenerator outlet and for silencing at the regenerator flue gas exhaust.

Pumps have been provided with spares, and pump drives are arranged to permit flexibility in balancing the steam and electric power loads. The large pumps have condensing turbine drives.

Detailed precautions have been exercised to minimize fire hazard. One feature is the installation of a permanent water fog spray system in the reactor-regenerator structure. Inspection and maintenance are facilitated by trolleys, hoists, platforms, and roadways, which make all equipment easily accessible.

● **Gas recovery system.** The light gas recovery system has been designed to recover approximately 70 per cent of the propane-propylene and 95 per cent of the butane-butylene produced in the thermal and catalytic cracking operations. Products will be separate streams of debutanized gasoline from the reformers, thermal crackers, fluid catalytic cracker and liquid C_3-C_4 polymerization unit feed.

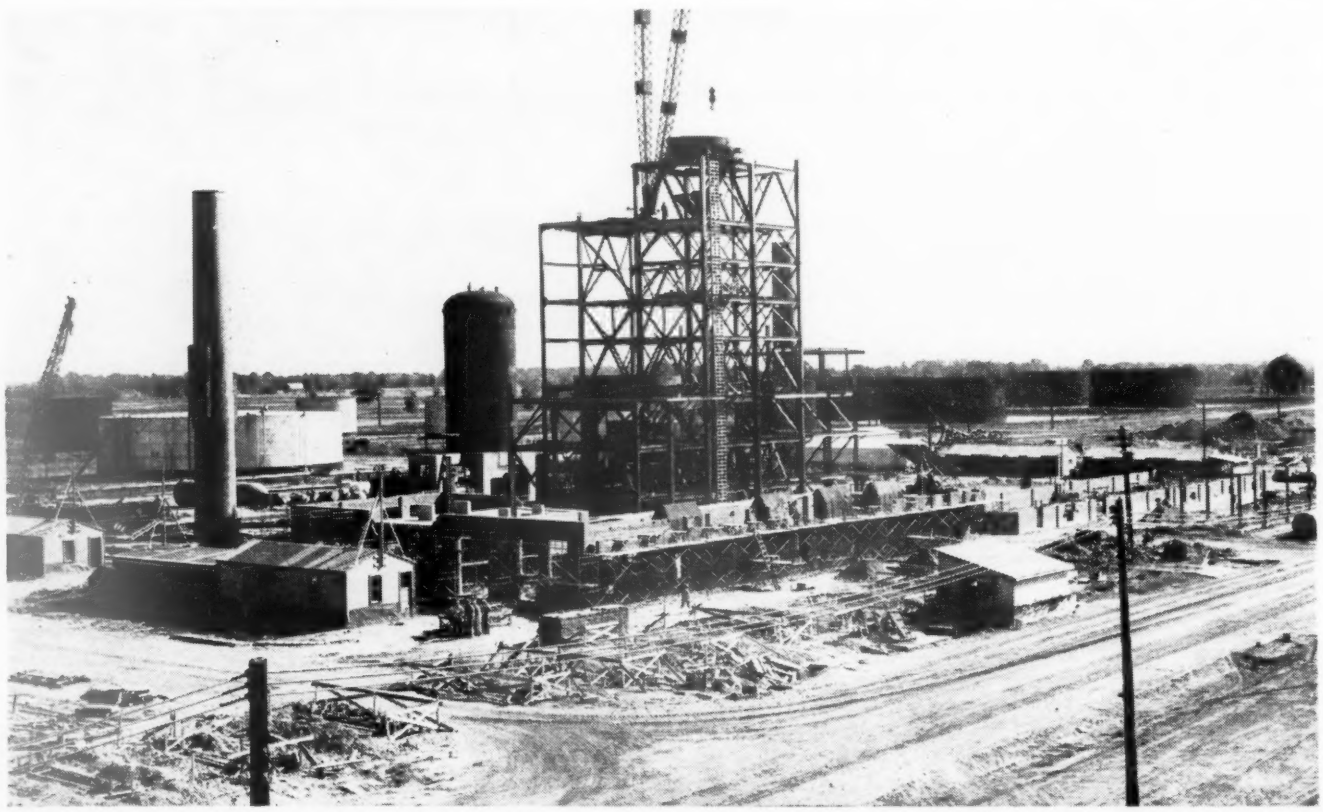
The present gas recovery equipment consists of a high pressure absorber, a debutanizer for the reformed gasoline.

The author, R. E. Luton

and a debutanizer for the cracked gasoline. The gases from the thermal cracker and reformer are combined and sent to a high pressure packed absorber, using reformer naphtha charge as lean oil.

The liquid from the reformer and thermal cracker receivers is sent to individual debutanizers, the bottom products thus being separate streams of debutanized thermally cracked and reformed gasoline. Overhead streams from each debutanizer are condensed and sent directly to the polymerization feed pretreatment. A Girbotol treating unit is being installed to remove hydrogen sul-

Setting vessel skirts of unit. Compressor building is in foreground.



Take a Tip From the Products You Use Every Day...

They're made with the aid of BECKMAN pH CONTROL!

WHAT ABOUT YOUR PRODUCT?

FEW PEOPLE—even those in industry themselves—realize the many diversified ways Beckman pH Control is being used to cut costs, reduce waste, improve operating efficiencies and insure a more uniform quality in dozens of products of daily use. For example . . .

The gasoline you use was probably refined with the aid of Beckman pH Control. Major refineries use Beckman pH Equipment to control the acidity of their processing operations, thus, not only improving the product, but also minimizing corrosion of costly plant equipment.

The paper you read in your magazines and books, as well as that which you use in your own catalogs and literature, are both made under the close control of Beckman pH Equipment. The paper mills manufacturing the finer qualities of paper use Beckman pH Control to regulate acidity in their processing operations and to insure more uniform printing qualities in the finished paper.

The sugar you eat was undoubtedly refined under the close control of a Beckman pH instrument—for accurate pH control has become an indispensable part of every well-managed sugar refinery.

The suit you wear, as well as your sox, shirt and other textiles you and your family use were probably produced with the aid of Beckman pH Control. It insures color-fastness, more uniform quality, greater strength in the finished fabric.

WHY NOT YOUR PRODUCT? Example after example can be cited where the job is being done better *for less* by means of Beckman pH Control. Chances are in *your* plant there are many important savings to be made through the installation of Beckman pH Control. Wherever there's water, there's pH—whether in chemical solutions, fluid pulps, moist pastes, sludges, industrial wastes or vat and tank processes. And wherever water or water solutions are used, chances are product quality can be improved, waste reduced and operating efficiency increased through the use of Beckman pH Control.

Why not find out about *your* product? Our trained engineering staff will be glad to work with you in recommending what can be done—possibly is already *being* done—in your particular field of industrial operation. *Beckman Instruments, National Technical Laboratories, South Pasadena 26, California.*

FACTS YOU SHOULD KNOW ABOUT BECKMAN pH EQUIPMENT

...that Beckman pioneered modern glass electrode pH equipment, transforming the cumbersome laboratory apparatus formerly used into a compact, practical portable instrument that paved the way for today's simplified pH measurement and control.

...that the first completely automatic glass electrode pH indicator, recorder and controller was pioneered by Beckman. Operating entirely without batteries, this instrument made automatic process control accurate, convenient, practical—and is today widely used in all parts of the world.

...that the only High Temperature Glass Electrode system available today is a Beckman achievement. This electrode system for the first time, enables continuous pH measurements to be made at temperatures up to 212°F (100°C) and is of tremendous value wherever hot process fluid must be controlled.

...that the only High pH Glass Electrode system is also a Beckman development. This is the only glass electrode that can be used to measure high pH values *even in the presence of sodium ions*...and extends the usefulness and accuracy of glass electrode equipment to many industries where alkaline solutions in combination with sodium ions have heretofore presented difficulties.

The above are only a few of many developments that make Beckman pH Equipment the only pH instruments embodying every *modern advancement* in the field of pH measurement and control.

FREE..."What Every Executive Should Know About pH"—a helpful, non-technical booklet containing much valuable information on the subject of pH—what it is—how it is used. Send for your copy today.

BECKMAN INSTRUMENTS CONTROL MODERN INDUSTRIES

New crude unit foundations and main laboratory structure.

phide from the charge to the polymerization unit. After this operation the charge will be subjected to separate caustic and water washes for final removal of small quantities of sulphur and nitrogen compounds. Sulphur compounds affect the lead susceptibility of the polymer, and nitrogen compounds are detrimental to the life of the polymerization catalyst.

The vent gases from the debutanizers are combined with the main receiver gases and are sent to the absorber of the thermal units.

New facilities will be provided for the recovery of the fluid catalytic cracking unit gas. The new unit will consist of two stages of compression, a high pressure absorber and a debutanizer.

The main lean oil stream for the high pressure absorber will be made up of the liquid from the interstage receiver of the compressor system and the liquid from the low pressure catalytic cracking receiver. A sponge stream of 400 F end point catalytically cracked naphtha from the main column will be charged over the top of the absorber to increase the recovery of butane and pentane. Debutanizer bottoms will be recycled over the main column as an additional absorption medium.

Fat oil from the absorber will be debutanized in the cracked gasoline debutanizer. The overhead will be combined with thermal unit stabilizer overheads and sent to the polymerization feed pretreatment unit. Vent gas from the debutanizer receiver will be combined with the second stage compressor gas as rich gas to the absorber. A common hot oil recirculating system is provided to reboil all three debutanizers.

● **Catalytic polymerization unit.** The polymerization unit has been designed for production of 1500 bbl a day of high octane polymer gasoline from 3800 bbl a day of charge stock. This charge stock will consist of debutanizer overhead from catalytic cracking, thermal cracking, and thermal reforming gas recovery units.

After being pretreated, the charge stock will be polymerized in high pressure shell and tube type reactors. The temperature of the catalytic reaction is controlled by boiling water around the catalyst tubes, thereby removing the heat of reaction. The generated steam preheats the feed stock. After pressure reduction, the reactor effluent flows to the depropanizer where the lighter hydrocarbons are separated and charged to the ethane column for LPG production. Lightest hydrocarbons are used for fuel.

High vapor pressure polymer from the bottom of the depropanizer flows to the debutanizer where polymer and excess butanes are separated.

● **Gasoline treating plant.** The straight-run gasoline treating unit is designed to handle either low end point or full range gasoline. It consists of a single stage caustic washer, continuous flow on the gasoline, and batch on the caustic.

Five new caustic storage tanks are being provided and two new caustic transfer pumps are being installed.

The catalytically cracked gasoline will receive a two-stage caustic wash. The main function of this treater is to remove phenols from the catalytic gasoline and, by operating the units so that caustic will flow countercurrent to the gasoline, it is estimated that the phenol content of the caustic in the first stage can be built up to 25-30 per cent before the caustic must be discarded. Provision has been made in the catalytic gasoline treating area for the future installation of another caustic washer and water wash, which may be used if a market for sodium phenolate of the order of 40 per cent concentration is obtained.

In order to insure stability of the cracked and polymer gasolines, equipment is provided for the immediate injection of inhibitor at each of the plants. To insure accurate control, the inhibitor measuring drums are mounted on indicating and recording scales. The actual injection of inhibitor will be done by Proportioneers equipment. The polymer gasoline will be inhibited continuously on its way to storage.

Ground was broken for the new construction last March and the plant is expected to be in operation midyear, 1948.

Ohio Oil Company also owns a refinery in Lovell, Wyoming, which processes 5000 bbl per day of heavy Wyoming crude, producing gasoline, distillate, road oils, and asphalts. ★★★

new and improved machinery and equipment

A REGULAR FEATURE
appearing in
THE *Petroleum* **Engineer**
Irwin-Keasler Building
Dallas 1, Texas

NEW EQUIPMENT

(1) Electric Hoists

The Ford Chain Block Division of American Chain and Cable Company, Inc., has announced a new line of electric hoists appropriately named Whippet. The Ford Whippet electric hoist has been designed to meet the demands of modern high speed production, it is stated. Rugged construction and low operating costs make this hoist adaptable for many heavy duty lifting jobs. The capacities of the Ford Whippet range from 250 to 2000 lb. They can be supplied with trolleys, either parallel or cross mounted. In addition, they can be provided with hook suspension or for rigid or bolt suspension. The standard lift of this sleek, smooth running, wire rope electric hoist is 12 ft; however, 20-ft lift can be provided when specified. These are a few of the Ford Whippet features: Easy to operate push button control; preformed wire rope and grooved drum provide safety and long wearing; all parts are easily accessible; motors meet NEMA standards; pull chain and handle supports push button station—is used to pull loaded or unloaded hoists along runway beams.

(2) Shot hole casing

A new shot hole casing for seismograph work is announced by Jones and Laughlin Supply Company, and the new product is now available through any of its stores from the Rocky Mountain region to the Atlantic coast.

Jones and Laughlin Steel Corporation makes this new shot hole casing of 3-in. OD 16-gauge electric-weld tubing in lengths from 10 to 20 ft. To achieve integral joint construction, the box end of each joint is expanded. The pin end is also expanded slightly to give a nominal ID clearance of 2⅞ in., and tapered to effect a positive seal. Heavy, square type threads, four to the inch, are then cold rolled into both ends, thus avoiding damage to the physical properties of the tubing.

Advantages pointed out by the manufacturer include: Independent couplings are eliminated. The rolled-in threads do not reduce the wall thickness as cut threads would, yet are easily matched by any machine shop should fittings be required. The square type, heavy rolled thread, only four to the inch, is rugged, hard to damage, and makes up and breaks out easily and rapidly. Sealing properties are improved. Great strength results in high recovery. Constant ID, with no projections, does away with the possibility of sticking or hanging the explosive charge in the casing.

The OD of the box is approximately 1⅝ in. The joint strength average is 15,000 lb and the joint is leak proof up to approximately 250 psi pressure.

Stocking points presently include Pampa, Odessa, Alice, Gladewater and Houston, Texas; Hobbs, New Mexico; Houma and Lake Charles, Louisiana; Laurel and Brookhaven, Mississippi; El Dorado, Arkansas, and Oklahoma City, Oklahoma.

(3) Hose attachment

The Justrite Manufacturing Company has announced the introduction of a new flexible hose attachment for Justrite safety cans used for storing and pouring flammable liquids. This new attachment may be applied to all Justrite safety cans of ½-gal or larger capacity manufactured since November, 1945. It is designed to facilitate the pouring of flammable liquids, lessening the hazard of spilling and dispersing of flammable vapors.

As described by the manufacturer, the hose attachment—Model No. 1088—consists of a 9½-in. flexible metal hose, a brass cup, and a removable strainer. A steel bracket holds the unit firmly attached to the can. When attached, the hose is flexible enough to be turned to any position, but is also rigid enough to remain in that position. It is especially adapted for use in hard-to-reach spots. This new hose attachment is available for immediate delivery, priced at $1.98 list.

(4) Deep well pumps

D + B Division of Emsco Derrick and Equipment Company announces the manufacture of a completely new line of deep well plunger pumps for corrosive and abrasive pumping service. Known as the D + B "Endurall" line, these new pumps are manufactured from a special stainless steel alloy that is highly resistant both to corrosion and abrasion.

The new D + B Endurall pumps are available in both rod and tubing sectional liner type pumps in a wide range of sizes and lengths to meet most pumping requirements. Liners, plungers, balls and seats, cages and miscellaneous fittings are also available for standard pumps now in service. All pumps and parts conform to API specifications.

(5) Lunkenheimer gate valve

Incorporating the first application of full cylindrical body sections to bronze gate valves, the new Lunkenheimer Fig. 2228 provides maximum distortion resistance, according to the manufacturer, The Lunkenheimer Company. Tests, setting up pipe line stresses and internal pressures far in excess of actual service conditions, have shown no distortion in body or valve seats, it is pointed out.

Fig. 2228 is a 200 psi S. P. bronze, double disk, "Union Bonnet" gate valve with rising stem and screwed ends. A companion valve, Fig. 2229, is the flange end pattern, rated at 150 psi S. P.; made in sizes ¼-3 in.

Among the features listed by the manufacturer are: A patented silicon alloy stem material that eliminates stem-thread failures; hexagon head gland; beveled disk wing guides and body guide channels to make assembly easy when servicing the valve.

(6) Recordomatic titrator

The first dual automatic recording device ever designed for plotting automatic titration curves, has been announced by Precision Scientific Company. The new device provides a permanent and complete record of titration curves, easily reproducible. It eliminates all work on the part of the operator, except that of preparing solutions and loading the feed unit. Titrations proceed rapidly, and since the device includes two complete titration set-ups, an important additional time-saving factor is introduced. While one sample is being titrated, a second sample may be prepared for analysis.

The "Precision" Dow Dual Recordomatic Titrator is designed for routine control work, as well as experimental research in chemical, industrial, and petroleum laboratories; for studying new reactions; for determining suitable indicators, for acidity determinations on petroleum products according to ASTM Method D-664; for Mercaptan determinations, among its many potential uses. The titrator is equally well suited for aqueous and non-aqueous media. It can be used with silver, antimony, platinum, calomel, or glass electrodes. There is no danger of polarizing the electrode system.

(7) Power slip

An improved power slip, with extensive field testing already behind it, has been introduced by Mission Manufacturing Company.

Operated by two air-actuated controls, the Mission "Super Speed" power slip is said to feature simplicity of design, ease of handling, and high speed operation. To engage the drill stem, the driller merely depresses a control lever mounted on the rig floor. This lowers the slip and allows it to grip the pipe. Elevators lift the pipe, and pressure on the other control pedal raises the slips.

The improved slips are said to save four to six months in round trip operation for every 1000 ft of well depth as compared with hand-operated slips. They also increase the safety of pipe handling at the derrick, and relieve the crew of a tiresome chore.

One advantage claimed for them is use of Mission's standard one-piece rolling dog slips, with substitution of new handles equipped with rollers. They take full advantage of the patented rolling dog feature, which allows instant gripping of the pipe without slipping, and instant letting-go without sticking.

The handling unit, made up of an operating post and lifting ring, is manufactured in one size. Use of different slips and rolling dogs, however, makes it adaptable to all sizes of pipe. When the slips are open, clearance is provided for tool joints, drilling bits, and the like, and the stationary lifting ring protects workmen from injury because it covers the moving rotary and shields men from the spinning slips.

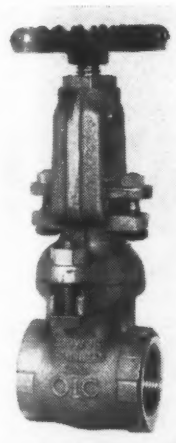
Drilling is not interrupted by installation of the slip, the experts agree. A rectangular hole in the derrick floor is cut for the operating post, which is bolted to a foundation beam. The pedal unit is bolted to the floor for operation by the driller.

To engage the drill stem, the driller depresses a control pedal, which lowers the slip to grip the pipe. Elevators lift the pipe, and a pressure on the other control releases the slips.

The lowering is so rapid that if elevators should fail and drop the drill stem when the slips are open, a quick pressure on the proper control will in many instances drop and close the slips in time to catch the pipe.

New Mission "Super-Speed" power slips, shown in raised or disengaged position for running or pulling the drill pipe (left), and in lowered or engaged position for making up or breaking out a stand of pipe.

(8) Stainless steel valve



A new corrosion-resistant stainless steel valve is set to join the growing line of products of The Ohio Injector Company. The new valve, built expressly for the chemical, processing, food industries, etc., wherever the service calls for corrosion-resistant valves, incorporates the same high quality that has earmarked OIC steel, iron, and bronze valves for 63 years.

The valve, manufactured in ½-in. to 2-in. sizes, is outside screw and yoke type, having bolted bonnet, tapered wedge, and screwed ends. It is so constructed that all materials in contact with the fluid are of low-carbon type 316 stainless steel. Packing and gaskets are corrosion-resistant. Yoke bushings, through which the stem rises, are renewable.

(9) Liquid filters

Wm. W. Nugent and Company, Inc., announce the manufacture of a new size of its Fig. 1116 bag type liquid filters; also its Fig. 1280 absorbent type liquid filters, both operating under pressure. This new size filter is known as Fig. 1116PY size 1S. When filtering lubricating oil of 200 SSU viscosity oil, the capacity is 2½ gpm at about 3 psi pressure drop through the filter or 7 gpm at 8 psi pressure drop through the filter. The 1S size filter is also made in an absorbent type using a cellulose material as a medium for the filtering.

When filtering lubricating oil of 200 SSU viscosity the capacity for a polishing job of filtering is 6.8 gpm at 35 psi pressure drop through the filter. If this filter is connected to an internal-combustion engine having a large oil circulating capacity the entire amount of the circulation from the pump may be piped to the filter and a 6.8 gpm mentioned above may be filtered, while a larger capacity of 16 gpm may be bypassed through a relief valve within the filter, thus greatly simplifying the connecting piping to and from the filter.

Both the bag type and the absorbent type filters have had more than a year's field test on high speed 200-hp diesels.

(10) Bowen rotary table

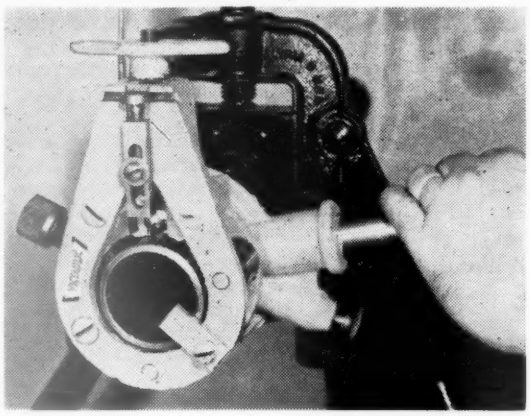
The Bowen portable and powered rotary table eliminates need of moving in and rigging-up heavy rotary equipment for light, short-time rotary operations, according to S. R. Bowen Company. In one easy to move, frame-mounted unit, the Bowen portable rotary table provides a powerful, sensitive rotary drive for such operations as the internal cutting or milling of casing, drill pipe and tubing, drilling out cement or other obstructions in casing or tubing, backing off sucker rods and tubing, etc. The method of operation is simple and direct and the sturdy, portable construction of the unit permits movement from rig to rig on the bed of a light truck or pick-up.

After the drilling or cutting string has been run in to the working depth, the complete Bowen portable self-powered rotary table is hoisted by its pick-up eye to a height sufficient to slide the slotted drive sleeve over the top joint of the working string. Once the pipe is centered in the drive sleeve, the entire unit is lowered to the floor and anchored by chaining opposite corners of the frame to opposing derrick legs. After anchoring the unit, slips of the proper size are installed in the two halves of dovetailed type drive bushings and the two halves made up on the string by tightening the drive bushing screws. Slips are available to fit from 3½-in. OD pipe to the smallest sucker rods. The working string is then lowered until the ears of the drive bushings are located within the slots of the drive sleeve.

With the ears of the drive bushings held in the drive sleeve slots, the string can be rotated and lowered under torque the length of the slot in the drive sleeve. Continuous operation is possible by loosening the drive bushing screws and again locating the drive bushings at the top of the drive sleeve. The string may be rotated and elevated under torque by locating the drive bushings at the bottom of the drive sleeve slot.

SMOOTHER RUNNING
Larger more efficient sealing area— for sealing in any type pipe
ONLY AMERICAN gives you the exclusive feature of a cup packing element which is expanded laterally . . . not compressed! And since all the seal is accomplished in one cup . . . there is no additional possible point of leakage! This fact, plus the larger sealing area of this packing element, also greatly overcomes interference from foreign matter such as steel cuttings or cement accumulations.
Smoother running
. . . because exclusive features of this AMERICAN Type G Packer provide ample internal fluid by-pass area for all safe running speeds!
A AMERICAN
IRON & MACHINE WORKS CO.
OKLAHOMA CITY, OKLAHOMA
Office, Houston, Texas
Export Office: 420 Lexington Ave., New York City, N.Y.

(11) Pipe groover



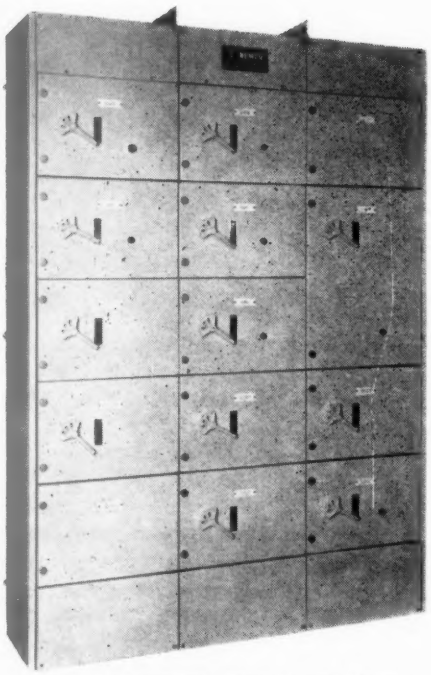
Victaulic Company of America, manufacturers of Victaulic couplings and Full-Flow elbows, tees, and other fittings, announces a new portable automatic pipe groover that easily and quickly converts plain end pipe so that it may be used with Victaulic couplings and fittings.

The new device known as the "Vic-Groover" may be operated either by hand or power and grooves pipe in half the time and half the effort required for threading pipe, according to the manufacturer. Cutting perfect grooves to the proper depth automatically, the "Vic-Groover" is light in weight and is easily carried to isolated locations for field grooving.

The "Vic-Groover" is available in sizes to accommodate pipe sizes of from ¾ in. to 4 in.

it's flexible . . .

CENTROL



Modern UNITIZED Low Cost Centralized Control Centers

- Standardized Prefabricated Sections
- Savings in Installation Cost—Wired Complete
- Saves Space
- Safe—Completely Dead Front
- Flexible—Additional Units Can Be Added Easily
- Smart, Modern Appearance

Class 1035 Centralized Motor Control Center

These Control Centers fill a growing need of industry for Centralized Control Equipment. In planning new industrial installations "CENTROL" equipment provides the latest in design and utility for load centers. Their Flexibility permits plant expansion or extension with minimum of delay and expense.

NELSON ELECTRIC MANUFACTURING CO.

217 North Detroit — TULSA, OKLAHOMA — Telephone 2-5131

MANUFACTURERS OF:

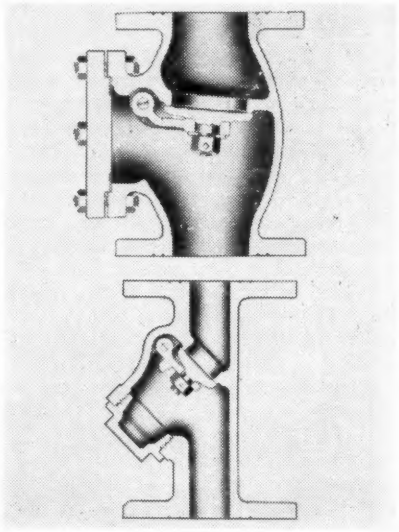
Explosion Proof Motor Controls
Junction Boxes and Enclosures
Circuit Breakers and Lighting Panels
Oil Field Motor Controls
Automatic Pipe Line Sampling Devices
Cathodic Protection Equipment
Switchboards
Instrument and Control Panels
Unit Substations

(12) Swing check valves

Crane Company has introduced new lines of corrosion-resistant swing-check valves in sizes ½ in. to 6 in. These valves, made in both 18-8 Mo alloy steel and Monel metal, are available in sizes ½ to 2 in. with screwed or flanged ends, and in sizes 2½, 3, 4, and 6 in. with flanged ends only.

In the sizes ½ to 2 in., the body is made in a Y-pattern, and the cap is on the same center line as the seat opening. The large cap-opening gives access to the internal parts when the cap is removed, so that seating surfaces can be reground without taking the valve body from the line.

In the 2½, 3, 4, and 6-in. sizes, the body is the straightway type, with the seat face at only a slight angle from vertical. This design permits full straightway flow, with a minimum of flow resistance and pressure drop.



Swing check valve.

The valves are recommended for liquid or gas working pressures up to 150 psi and for a maximum temperature of 350 F.

(13) Protective coatings

New lines of protective coatings for metal surfaces, and waterproofing compounds for use with concrete have been announced by the manufacturer, Consolidated Sales Agency. Having the trade name of Consa-Lite coatings, the new products are made from a base of pure Wurtzelite gum combined with naphtha and mineral solvents to produce required consistencies. The materials have been widely tested by application to metal and wooden tank surfaces, as coatings on the interior of pipe, and in similar industrial usages. It has been found especially good as a resistant to

sulphuric acid and sulphuric acid fumes, it is asserted.

Pipe insulated with Consa-Lite suffers no damage from soils that have either an alkaline or acid content, it is stated. The compounds have proved that they possess high insulating qualities, among which is a tremendous dielectric strength rated at 1/1000 in. per mil. Marine growths do not adhere to surfaces treated with Consa-Lite. The manufacturer adds the information that Consa-Lite will not crack, check or alligator.

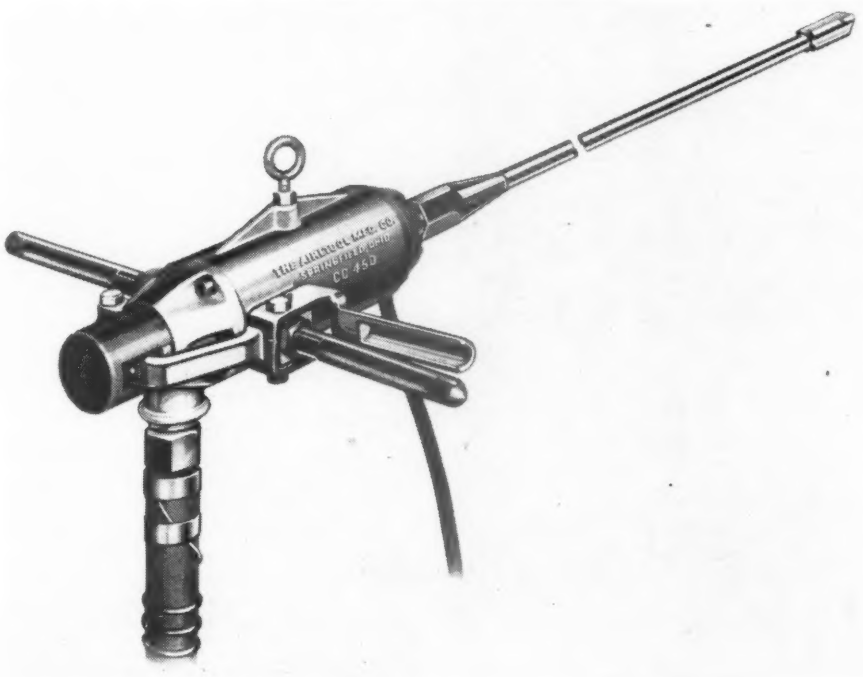
(14) Direct-drive cleaner

The Airetool Manufacturing Company is now manufacturing a direct-drive cleaner weighing only 21 lb. It is particularly designed for cleaning all scale conditions from condenser and heat exchanger tubes from ⅜ in. to 1½ in. ID. This new Model CC-450 Airetool cleaner can be used with or without a supporting rig.

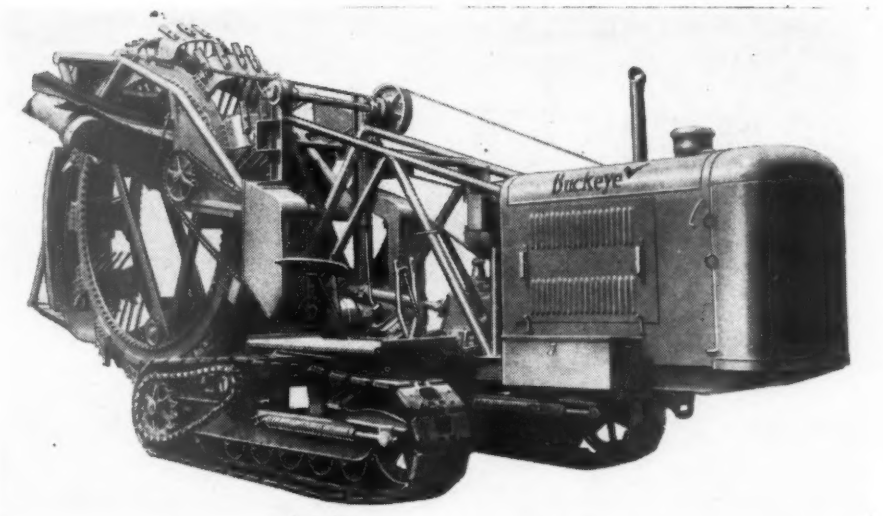
The outer case is of sturdy, lightweight aluminum alloy. All moving parts are made from alloy steel that is heat treated to insure uniform grain and hardness. A convenient handle valve affords the operator constant, positive control and the direct drive, high speed motor is air or steam driven.

This cleaner also employs Airetool's featured slip-fit construction, which permits quick disassembly of the motor on the job, without special tools. The flushing agent is introduced through the motor and the drive shaft to the cutting edges to insure a cool drill and to flush out the removed deposit. The packing glands of this cleaner prevent leakage of the flushing agents.

Various designs of cutters and drills are available for use with this cleaner.



Model CC-450 Airetool cleaner.



Model 312 pipe-line ditcher.

(15) Continuous mixer

A new continuous mixer, designed to eliminate batch mixing in the process industries, is announced by Marco Company, Inc.

Known as the Roto-Feed Continuous Mixer, the modern equipment provides a means for converting batch mixing into a single, continuous operation under accurate, uniform control, it is stated. This occurs continuously. It is only necessary to proportion the desired ingredients into the Roto-Feed, and they emerge thoroughly mixed at a controlled rate of 5 to 1000 gal per hr.

The Roto-Feed Continuous Mixer is stainless, sanitary, easy to clean. It requires comparatively little space and is easy to set up and operate, according to the manufacturer.

(16) Pipe-line ditcher

The new Model 312 ditcher illustrated, which succeeds the widely used Model 12, has been placed on the market by Gar Wood Industries, Inc., Findlay Division.

The Model 312 is ideal for gathering lines, short loops, small product and gas lines, and for work around tank farms, refineries, and terminals, the manufacturer points out.

Compared with its predecessor, this new ditcher offers greater range, simplified controls, and better balance. Model 312 is built for longer service, faster digging, and reduced operating and maintenance costs.

Model 312 cuts ditch 16 in. to 30 in. wide (depending upon the buckets used) and up to 6 ft deep, as compared to the 5½ ft maximum cutting depth of the old Model 12. The digging wheel is supported by a rugged frame made of tubular members, a design that has proved its advantages in aircraft construction. Model 312 is several inches shorter than the old Model 12, and approximately 500 lb lighter. Its diesel engine develops 67 hp at 1600 rpm. A fluid coupling in conjunction with a friction clutch permits loads to be picked up or relieved with either or both. Digging speeds up to 57.5 fpm are provided. This is more than 50 per cent greater than the maximum digging speed for the former Model 12. The new ditcher has four forward and four reverse road speeds.

(17) Microflo control valve

The Microflo control valve with spline plug can handle flows in cc's with pressure drops in thousands of pounds. The basic element of the valve is a solid stellite valve plug, which is a honed fit in a solid stellite seat. Clearances between plug and seat cannot be measured by ordinary methods, yet galling does not occur because of the type metal used.

Physically the flow control section of a spline plug is ¼ in. OD by 1⅝ in. long. It is a selective lapped fit in a

⅝ in. deep seat. This seat depth insures streamline or viscous flow just as the plug is leaving the seat. Flow control in the 1 in. of valve travel is governed by the shape of slots or grooves milled into the plug surface—hence the name "Spline Plug."

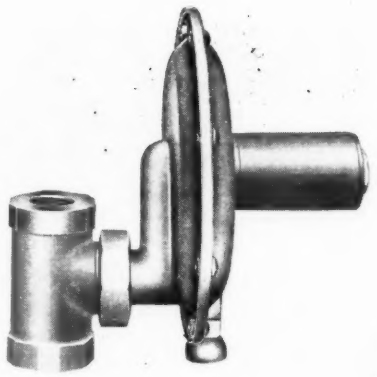
These valves can be provided in any body-size of ½ in., ¾ in., or 1 in. The actual size of these valves is below 3/16 in. normal rating. There are fifteen interchangeable valve plugs for seats numbered 1 through 15.

These valves can be ground in for tight shut-off. All valves have a rangeability of 50:1 or greater, the seat is a lapped piloted fit in the valve body. It is held in place by a threaded retainer that clamps it in the valve body. In the event new operating conditions require a valve with different capacity, it is merely necessary to back out the threaded retainer and replace the plug and seat with another one of the proper trim size.

Manufacturer of the Microflo control valve is Hammel-Dahl Company.

(18) Gas service regulators

Universal gas service regulators are especially suitable for engine fuel service on gas engines utilizing natural gas, butane, or propane for fuel. They are available in ¾-in. 1-in., and 1¼-in. pipe sizes as Type No. 47 is especially suited



for engine fuel service. Type 47-R with a built-in relief valve is more commonly used for domestic gas service ahead of a domestic gas meter.

The regulators incorporate for the first time stamped steel construction rather than cast iron, the manufacturer states. This provides greater strength and has materially reduced the shipping weight. The steel is cadmium plated, inside and out, to resist corrosion.

A very important feature is the location of the diaphragm in a vertical plane to permit drainage of atmospheric moisture from the atmospheric side of the diaphragm. Likewise, the design permits drainage on the gas side of the diaphragm to prevent accumulation of any liquid. Union nut connection between regulator body and diaphragm casing permits positioning body for installation in either horizontal or vertical pipe run.

Beside engine fuel service on single and multi-cylinder engines they also find application for reducing gas pressure for fuel to oil field type heaters and treaters.

(19) Dodge sheave

A solid steel fractional horsepower variable pitch sheave providing finer adjustment through use of 20 threads instead of 16 has been announced by Dodge Manufacturing Corporation. This sheave is made in the following range of pitch diameters:

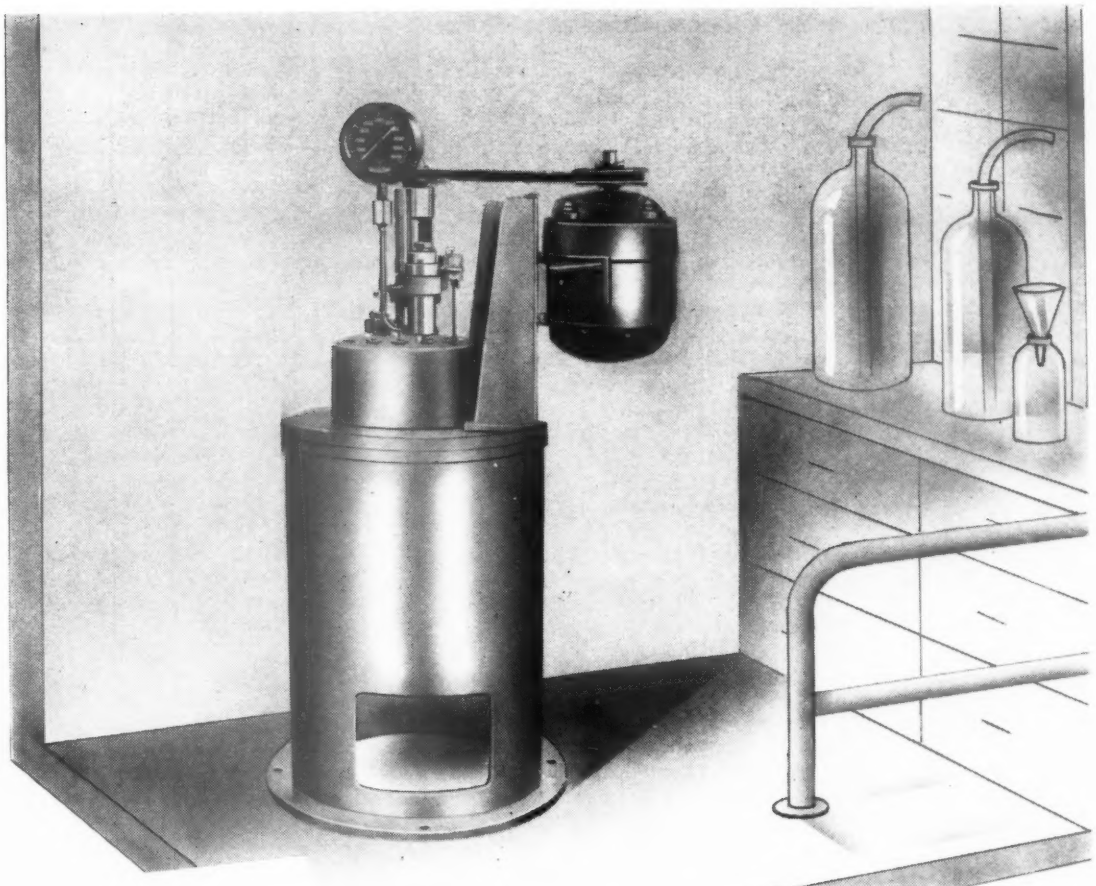
Using No. 2 FHP belts	Using No. 3 FHP belts
1.9 to 2.9 in.	2.4 to 3.2 in.
2.4 to 3.4 in.	2.7 to 3.7 in.
2.8 to 3.8 in.	3.1 to 4.1 in.
3.4 to 4.4 in.	3.7 to 4.7 in.

All sizes of sheaves will be available in three standard bores, namely, ½ in., ⅝ in., and ¾ in. The ½-in. bore sheave is provided with set screw only but the ⅝-in. and ¾-in. bore sheaves have both keyway and set screw.

(20) Joint compound

Dra-Led joint compound, a product of the C. H. Dragert Company is offered as protection against drill collar washouts. Composed of 90 per cent metallic lead, Dra-Led is anti-galling and is recommended by many drill collar and tool joint manufacturers for maximum efficiency, the manufacturer states.

The Continental Supply Company is exclusive distributor for the oil country.



ONLY
$850.00

A Complete High Pressure RESEARCH LABORATORY

With high pressure research entering wider fields of the process industry -- with research labs from food to petroleum showing a keen interest in high pressure research, the need for a compact, self contained, high pressure autoclave is quite evident.

In answer to this challenge Autoclave Engineers, Inc. have designed and built the one liter autoclave pictured above.

Virtually a complete high pressure laboratory

Self contained, completely new in design, this one liter autoclave incorporates all of the major improvements generally found only in much higher priced, custom built equipment. Consisting mainly of a one-liter stirred reactor, this unit is built for working pressures to 5,000 p.s.i., working temperature to 650° F., with agitator speeds variable from 300 to 1,000 R.P.M. Because this unit offers positive agitation at known rates of speed, it allows the chemist to carry out reactions involving suspended catalysts in quantities as low as 150 cc. Agitator shaft is sealed and protected with special packing assembly, which permits operation with a wide range of gases -- from light hydrogen to heavy ammonia at high pressures and high temperatures without leaking and without galling the shaft.

Write for detailed specifications and literature 5-C.

AUTOCLAVE ENGINEERS INCORPORATED

DESIGNERS, MANUFACTURERS & DISTRIBUTORS OF LABORATORY & PILOT PLANT HIGH PRESSURE EQUIPMENT

3737 WEST CORTLAND STREET . . . . CHICAGO 47, ILLINOIS, U. S. A.

trade literature

PUBLICATIONS LISTED ARE SENT FREE UPON REQUEST

(21) Oil purifier maintenace

The Hilliard Corporation, Oil Purifier Division, has two new booklets on oil maintenance equipment: One, describing the complete line of Hilco oil reclaimers, Airline oil purifiers, and Hyflow oil filters; and the second covering Hilco equipment for the proper maintenance of lubricating and fuel oil for diesel locomotive operators.

(22) FWD trucks

New literature describing FWD trucks available for mounting ready-mixed concrete bodies is announced by The Four Wheel Drive Auto Company. Titled "Mixers on the Move," the folder describes use of its trucks in capacities ranging from 20,000 to 38,000 lb gross vehicle weight for use with mixers from two to five and a half yards capacity.

(23) Conditioning handbook

Advanced and modern methods and apparatus for conditioning water and other liquids are described in a 60-page bulletin completed by Liquid Conditioning Corporation, manufacturers of Liquon equipment and Liquonex materials for water softening and clarification. The bulletin is a revision of a previous publication, which has been brought up to date to include the most recent developments in the design of water treatment and liquid conditioning equipment. Each of the many different types of water conditioning processes are described and the applications, advantages, and limitations of each type are explained. Included in the material specially developed for the bulletin are tables listing the various kinds of gaseous and solid impurities, showing the effects, limits of tolerance for various purposes, methods of removal, and residual amount of each impurity after treatment; and also a comparison chart showing the chemical results produced by various water treatment methods.

(24) Hobart arc welders

The Hobart Brothers Company now has available a new 36-page, 3-color catalog containing illustrations, descriptions, dimensions and specifications on its complete line of "Simplified" arc welders, which includes electric motor driven d-c welders in five sizes from 150 to 600 amp; gasoline engine driven welders in four sizes from 200 to 600 amp; a-c transformer type welders in three sizes from 200 to 500 amp; welding generators only in four sizes from 150 to 400 amp; gasoline engine driven welders with auxiliary a-c or d-c power generators, and other models in all sizes for special arc welding applications. Various features comprising the machines are individually illustrated and described, and helpful information is given for various welding problems. Also listed is the complete line of Hobart arc welding electrodes and accessories.

(25) Boiler and tank accessories

A catalog on forged boiler and tank accessories has been published by The Steel Improvement and Forge Company that gives complete buying information on manhole and handhole plates and yokes. This 20-page booklet contains illustrations, dimensional drawings, tables of weights and sizes, and descriptive information on manhole covers and yokes, handhole covers and yokes, welding street ells and water column ells. Comparable designations giving chemical propositions and tensile properties of the products as well as hydrostatic test data are presented. Information about curving handhole covers aids the users of this product.

(26) Guide to Micromax instruments

For instrument men in scientific laboratories and industrial plants, Leeds and Northrup has published a new 16-page catalog that will serve as a handy guide to all their round-chart Micromax instruments. Called "Micromax Model R—Indicating Recorders and Controllers," this publication is not limited to those instruments used to measure any one quantity, using any one primary element, but, for the first time, it presents all Micromax Model R's, regardless of whether they are supplied to measure temperature, through the use of thermocouples, Rayotubes or Thermohms, or other quantities such as frequency, gas analysis, electrolytic conductivity, and pH.

Included are complete specifications in easy-to-use, tabular form for automatic indicating recorders, and indicating and recording controllers.

(27) Axial air gap motor

The Fairbanks-Morse axial air gap motor is shown and described in a bulletin recently made available. The axial air gap motor is distinguished from the conventional type of motor by the fact that the air gap dimension is measured parallel to the axis of the shaft, as compared to a radial dimension in the conventional machine. It is from this contrasting feature that the motor derives its name—axial air gap.

(28) Fuel oil units

"Fuel Oil Pumping and Heating Units" is the subject of a bulletin issued by National Airoil Burner Company, Inc. The units are used to prepare heavy fuel oil for combustion, for all types of oil burners.

(29) Automatic self-priming pump

Allis-Chalmers' automatic, self-priming pump equipped with a new type automatic spring valve that is said to give faster, smoother transition from priming or vacuum pumping to straight centrifugal action, is described in a new 8-page illustrated bulletin released by the company. According to the bulletin, the pump's portability, rapid installation, quick priming features, and non-clog design of its open impeller types, makes it a valuable tool in almost every industry. It is adaptable to any drive and is available in five sizes to cover ranges and conditions diagramed in the bulletin. The pump's simple design, which is graphically portrayed, makes for easy maintenance of its vital parts.

(30) Corrosion-resistant angle valves

A new bulletin released by The Duriron Company, Inc., describes Durco corrosion-resisting, Series 35 Y valves and Series 36 angle valves and shows their internal construction by means of cutaway views. These illustrations bring out every construction detail and show, in color, exactly which parts of the valve are made of a special corrosion-defeating Durco alloy. Features are listed and a brief explanation of the type of service for which the valves are best suited, is given. The bulletin provides complete dimension data on the various sizes and includes an illustrated parts list. The folder also tells how the valves can be equipped with air-operated diaphragm motors for automatic regulation of the flow of corrosive solutions.

(31) Plastic lined pipe

As a result of several years' research, the Amercoat Division of American Pipe and Construction Company has developed plastic lined steel pipe to permit the handling of strong chemicals. Plastic lined steel pipe combines the structural strength of steel with the well-known chemical resistance of Vinyl resins, and permits handling strong chemicals in ordinary steel pipe.

(32) National rotary and swivel

The National Supply Company has issued a new 12-page, well illustrated bulletin on the Ideal MS-20½ rotary machine, designed for medium speed drilling and for moderately deep holes. The bulletin, No. 342, supersedes Bulletin No. 299. It includes specifications, line drawings, general description of main parts, including spiral bevel gear, and lubrication.

Bulletin No. 346 of the same company describes and profusely illustrates the Ideal Type D swivel, a medium swivel rated at 150 tons at 150 rpm. The bulletin includes specifications, life expectancy chart showing the influence of loading and speed on the performance of the main bearing, and a description of construction, design, and materials in the D-swivel and accessories, with "exploded" and cutaway views of parts and assembly.

A New

TRUSS TYPE SUBSTRUCTURE

for Standard Derricks!

This new Truss Type Substructure is designed with greater capacities, sturdier welded fabrication and reduced structural weight.

Sizes are 24 ft. and 30 ft., either 4 post or 8 post, nominal heights of 10'-4" and 14'-4". Corner capacities are 1,000,000 and 1,400,000 lbs.

For increased adaptability of the standardized units the side and interior trusses, rotary beams, etc., for the two sizes are interchangeable between the 4 post and 8 post arrangements.

Any LEE C. MOORE office listed below will supply complete information.

(33) Robins idlers

Vital information necessary for laying out a belt conveyor system is contained in a new bulletin on Robins Idlers, which has just been issued by the Robins Conveyors Division, Hewitt-Robins, Inc. The new bulletin, No. 120-A1, amplifies the previous issue, incorporating important changes in engineering details. It also points out features of the Robins Idlers, such as one-shot lubrication, triple grease seal, rigid truss construction, malleable iron brackets, channel bases, minimum clearance between pulleys, and uniform wall thickness of pulleys.

(34) Sperry Knockometers

New mailing pieces describing Knockometers for automotive and aviation fuel testing on single cylinder laboratory engines have been issued by the Sperry Gyroscope Company, Inc. The literature describes the operation and the specifications of Knockometer models K-1 (aviation) and K-3 (automotive) under publications No. 15-46 and 15-47, respectively.

(35) Vapor saving system

The method of determining which of the flat-bottom tanks in a vapor-saving system to equip with a lifter-roof and the method of computing the correct sizes of vapor lines connecting the tanks is described in a new 12-page booklet recently completed by the Chicago Bridge and Iron Company.

The vapor pressure of the stored product, the expansion of the air-vapor mixture, and the flow of vapor in the vapor lines can be read directly from the charts and tables included in this booklet. The details of the Horton liquid-seal lifter roof tank are shown in several elevation, plan, and sectional drawings.

A typical vapor-saving system including three cone roof tanks and one Horton lifter-roof tank is shown in a diagrammatic sketch supplemented with the necessary calculations for designing the system.

(36) Oil tool specialties

M. O. Johnston Oil Field Service Company has published informative literature on two of its oil tool specialties.

An 8-page perf-test brochure describes the construction and uses of the All-Purpose Johnston Gun Perforator and tells how it functions in combination perforating and formation testing operations.

A comprehensive treatise on the Johnston Formation Tester explains the engineering features as well as accessory equipment and gives detailed instructions and illustrations on all phases of formation testing.

(37) Testing sieves

Newark Wire Cloth Company announces the availability of a new 4-page folder describing the Newark line of ASTM testing sieves and the Newark "End-Shak" testing sieve shaker.

(38) Choice of electrodes

A clear, concise bulletin entitled, "What Electrode to Use to Weld a Specified Stainless or Alloy Steel," has been published recently by Arcos Corporation. The subject is divided into sections for easy reference, and provides information on base metal identification of solid and clad materials, recommended types of electrodes, special considerations involving corrosion, heat or strength properties, as well as suggestions for welding dissimilar metals. Also included is a complete chart of the trade names of stainless alloys as produced by the mills of the country.

(39) Precision products

The Falk Corporation announces the release of its new Bulletin 10,000, which has received national recognition for Falk in a nationwide competition for industrial sales literature. Descriptions and illustrations of all Falk precision products, such as, gears, speed reducers, Motoreducers, couplings, high speed drives, backstops, marine drives, and special gear drives are contained in this bulletin. Available services and facilities including steel casting, machining weldments, and engineering are also described.

(40) "Remanufactured" engine folder

A folder showing the process used in "remanufacture" of General Motors diesel engines has been published by Stewart and Stevenson Services. This brochure gives the prices on both stationary engines and GM engines in Allis-Chalmers tractors, together with a description of the "remanufacturing" process.

Advantages asserted for this method of "overhaul" are: (1) Overhaul time practically eliminated, (2) "Remanufactured" engine may be shipped freight prepaid anywhere in Texas before old engine is removed; old engine is then shipped to Houston, freight collect, (3) a guaranteed flat charge for the completed engine, (4) same Stewart and Stevenson guarantee that accompanies new engines.

(41) Going places on rubber

High speed, off-road hauling is discussed in the recent "Caterpillar" publication "Going Places on Rubber." Rubber tired equipment is described operating on a range of jobs where high speeds are required on long hauls.

The booklet presents the equipment best suited to handle the situation encountered on such operations as rock work, leveling and filling, and should be of interest to all readers who desire information concerning the efficiency and best economic possibilities on such jobs.

(42) Metal tubing circuits

An authoritative handbook on the selection, sizing, layout, and installation of metal tubing circuits has been published by The Parker Appliance Company. Called the Tube Fitter's Manual, the handbook makes available in printed form all basic data underlying the specialized techniques required for the design and speedy installation of long-life, leakproof systems. The 76-page manual should be particularly useful to personnel of design, assembly, and plant engineering departments of companies throughout industry generally.

(43) Filter press bulletin

A new 16-page bulletin describing filtering operations, materials of construction and the five major filter press models, is offered by Valley Foundry and Machine Works, Inc. The new hydraulic closing device developed by Valley engineers for use in connection with its own or other filter presses is described in detail. Said to be the latest type of hydraulic closing device in the field, the unit features finger-tip control and sure-sealing action.

(44) Radioactivity measurements

A 12-page monthly publication, issued by Tracerlab, Inc., contains the latest developments in equipment design for radioactivity laboratories and technical articles of general interest on the chemical, electronics, and physical aspects of radioactivity. Issue 7 of *Tracerlog* includes articles on radioactivity measuring equipment, radioassay techniques, radioactivity reference sources, absorbers, and radiochemical services.

(45) Industrial floats

Chicago Float Works, Inc., announces a new issue of its catalog, which describes in detail the complete line of copper, steel, monel, and stainless steel industrial floats offered by the company. It includes engineering data necessary to make volume and buoyancy calculations, together with diagrams of standard float connections used with float valves and liquid level controllers. Also pointed out in the catalog is Chicago Float Works' service in the preparation of detailed recommendations to suit individual float requirements, standard or special.

(46) Oil country equipment

Link-Belt Company has issued Book No. 2080-A, describing its oil country equipment. Included are illustrations and descriptions of Silverlink roller chain, "SS" class rotary chain, cut tooth sprocket wheels, mud screens, speed reducers and speed increasers, Silverstreak silent chain drives, flexible couplings, ball and roller bearing units, shovels, draglines, and cranes.

(47) Torque converter tractor

A 6-page folder describing Allis-Chalmers' new HD-19 torque converter tractor is now being distributed by the company's tractor division. A 3-page center spread heralding the HD-19 as the "World's Largest, Most Powerful Tractor" lists many of the new unit's prominent features such as its 40,000-lb weight, 163 net engine horsepower, and its hydraulic torque converter drive.

FULL of *Power* ful Facts...

Mr. Operator, if you would take time to see the actual case history of how efficiently and economically Utility Electric Power is utilized in business similar to yours, and in operations of every kind, you would be surprised how much money can be saved annually. All we ask is a few minutes of your time. Just call The Power Engineer over for a conference. Your local Utility Electric Power Company will send him—at no cost or obligation to you. The Power Engineer is the man with the know-how, the man to help you plan adequate, dependable and economical power.

Use Utility Electric Power!

PETROLEUM ELECTRIC POWER ASSOCIATION

Box 1498, Oklahoma City, Oklahoma

Acquires firm

Koppers Company, Inc., Pittsburgh, has acquired all stock of the Manufacturers Chemical Corporation and its sales subsidiary, the Chemaco Corporation, both of Berkeley Heights, New Jersey.

Dan M. Rugg, vice president and general manager of Koppers Chemical Division, which will operate the newly acquired plant, and Henry Harding, Manufacturers' president, said in a joint announcement that the purchase was made by issuing shares of Koppers common stock to the owners of the purchased corporations in exchange for their previous holdings.

The newly acquired companies will be operated as wholly-owned subsidiaries of Koppers.

All personnel of Manufacturers and Chemaco will join the Koppers organization under present plans, Rugg said. Operations of the Chemaco Corporation will be integrated with those of the Koppers Chemical Division sales department. Henry W. Harding, president of Manufacturers, will become assistant sales manager of the Koppers Chemical Division; Karl M. Joehnck, vice president and production manager, will become manager of the Manufacturers' plant; and Walter J. A. Conner, vice president and sales manager, becomes assistant eastern district sales manager for Koppers, Chemical Division.

Fred Hummel consultant

With two laboratories at his disposal, one portable and one fixed, Fred E. Hummel, widely experienced metallurgical engineer, formerly of Shell Oil Company, Inc., has launched out on his own as a consultant, specializing in the chemical control of drilling fluids. Hummel, who now makes his headquarters at Ojai, California, plans to cover the coastal fields from Castaic north, and is already handling a considerable volume of consulting work on various drilling and production problems. He is a graduate of the School of Mines and Technology, South Dakota, where he received his B.S. in metallurgy in 1931, and his M.E. in 1935, for research work in electrolytic gold, platinum, and paladium refining. Since 1935 he has been employed by Shell Oil Company.

Fred E. Hummel

Regan Forge & Engineering Co.

Quality

SAN PEDRO, CALIFORNIA

HOUSTON, TEXAS, U.S.A.

BAKERSFIELD, CALIFORNIA—Telephone, Bakersfield 34204

EXCLUSIVE MID-CONTINENT REPRESENTATIVES: Hunt Tool Company, P. O. Box 1436, Houston, Texas

EXCLUSIVE EXPORT REPRESENTATIVES: Hunt Export Company, 19 Rector Street, New York City, N. Y. • Avda Pte. R. Saenz, Pena 832, Buenos Aires, Argentina

Statement of the Ownership, Management, Circulation, etc., Required by the Acts of Congress of August 24, 1912, and March 3, 1933, of

THE PETROLEUM ENGINEER

Published monthly at Dallas, Texas for October 1, 1947.

State of Texas, County of Dallas, ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared W. T. Bryan, who, having been duly sworn according to law, deposes and says that he is the Business Manager of

THE PETROLEUM ENGINEER

and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher: The Petroleum Engineer Publishing Co., P.O. Box 1589, Dallas, Texas.

Editor: K. C. Sclater, P.O. Box 1589, Dallas, Texas.

Managing Editor: F. H. Love, P.O. Box 1589, Dallas, Texas.

Business Manager: W. T. Bryan, P.O. Box 1589, Dallas, Texas.

Advertising Manager: T. J. Crowley, P.O. Box 1589, Dallas, Texas.

2. That the owner is a partnership composed of W. T. Bryan, T. J. Crowley, W. L. Love and K. C. Sclater, all of Dallas, Texas, doing business under the name of The Petroleum Engineer Publishing Company.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustees or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has an interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

W. T. Bryan, Business Manager.

Sworn to and subscribed before me this 29th day of September, 1947.

[Seal] Edwina H. Cameron

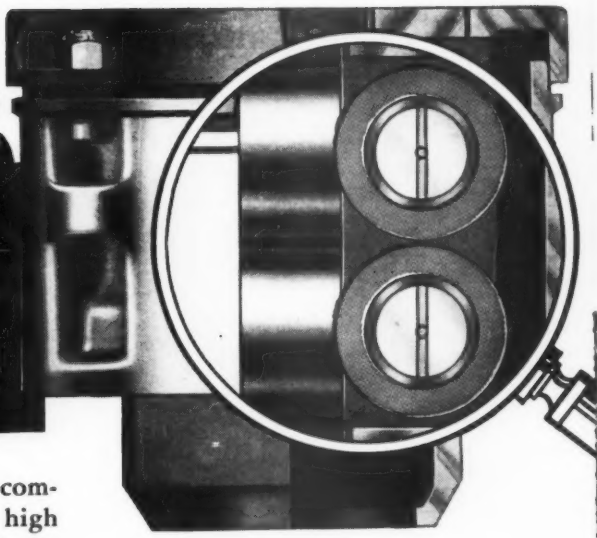
(My commission expires June 1, 1949.)

Baash-Ross News

BAASH-ROSS TOOL COMPANY • LOS ANGELES • HOUSTON • NEW YORK

OUR 27th YEAR

There's as much difference between this and this ...as between this and this



That's why the BAASH-ROSS ROLLER KELLY BUSHING makes 6 vital savings in drilling operations!

IF you want to know whether or not your rig operations are completely up-to-date *look at your kelly bushing.* If, under modern high speed drilling operations, you are still trying to *slide* the kelly through the bushing instead of *roll* it through, you're bucking the same kind of friction you'd get by dragging a load of drill pipe instead of rolling it on wheels.

Here's why: Some operators think that, because the drill string is hanging vertically in the rig, it will drop through the table without friction when the weight is fed off. It will—*as long as no driving pressure is being applied by the rotary table.* But as soon as the table starts rotating the drill string, pressure is built up between the bushing and kelly... pressure that becomes greater and greater as table speeds and the length of the drill string increase.

This driving pressure becomes so great under today's high speed drilling operations that the kelly simply cannot feed off freely when the brake is lifted. Bit feed becomes jerky and erratic. Too much weight is applied... the bit "digs in"... and the damaging torsional loads set up in the drill string cause costly "twist-offs" and pin failures. In addition, table and swivel bearings are subjected to surging impact loads and the life of virtually every piece of equipment in the drill string is substantially shortened.

But—WITH A BAASH-ROSS ROLLER KELLY BUSHING the rollers insure instant response to kelly feed *regardless of driving pressure between bushing and kelly.* Instant response means accurate weight control... faster drilling... straighter hole... and minimum torsional loads to damage the drill string or rig equipment.

When you put a Baash-Ross Roller Kelly Bushing on your rig you can count on making at least 6 important savings...

1. **MORE ACCURATE WEIGHT CONTROL** because—even at table speeds as high as 1000 r.p.m.—there is no friction between bushing and kelly to hold up the drill string or prevent instant weight response.
2. **STRAIGHTER HOLE** because bit feed is controlled more accurately and excessive weight is eliminated.
3. **MORE HOLE PER BIT** because the bit can be kept digging at a more uniform and efficient rate without damaging load surges.
4. **REDUCED DRILLING COSTS** because longer bit life means more time on bottom, less time wasted on round trips.
5. **MINIMUM DRILL STRING DAMAGE** because sensitive roller kelly feed eliminates over-feeding and the sudden torsional loads that cause twist-offs and thread damage.
6. **MAXIMUM EQUIPMENT LIFE** because drilling lines, swivel and table bearings, and other rig equipment are all protected against the destructive impacts of over-feeding.

ADVANCED CONSTRUCTION FEATURES

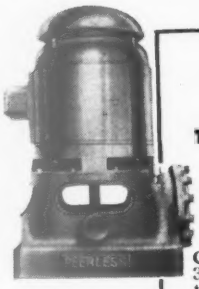
Baash-Ross pioneered the roller kelly bushing principle and through the years has made one important design advancement after another that insures maximum service life and minimum maintenance on even the heaviest drilling service. • Two Rollers against *each* kelly face prevent wobble and gyration of the drill string • Replaceable Bronze Bushings between rollers and pins take practically all the wear • Reversible Pins can be rotated to double the life of the pins • Solid One Piece Cover is completely streamlined for maximum safety and strength • Positive Shim Adjustment in hex kelly bushings simplifies maintaining the proper clearance essential with hexagonal kellys... These and many other features mean maximum operating efficiency and long service life when you install a Baash-Ross Roller Kelly Bushing.

Why not investigate *today* the multiple savings you can make in your drilling operations by installing a Baash-Ross Roller Kelly Bushing. They are available in sizes to fit all popular kellys from 2½" to 6" in the square type... from 3" to 7" in the hexagonal type. Each size Bushing can be quickly adapted to a wide range of kelly sizes by simply changing roller assemblies, thus minimizing inventories and simplifying changes in kelly sizes.

Get all the facts from your Baash-Ross representative on the many savings you can make by installing a Baash-Ross Roller Kelly Bushing. Or write direct.

Peerless

Builds the Pump you require in Vertical



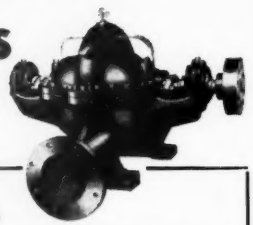
PEERLESS DEEP WELL VERTICAL TURBINE PUMPS

Oil or Water Lubricated Types

Peerless Moturbo Drive illustrated

Capacities: 15 to 30,000 g.p.m.; Lifts: to 1300 feet; Drives: electric, gear, belt or combinations. For wells 4" inside diameter and larger. Embodies patented Double-Bearing and Double-Seal Bowl construction.

and Horizontal Types



PEERLESS TYPE A CENTRIFUGAL PUMP

General Specifications: Capacities: 50 to 70,000 g.p.m.; Heads: 15 to 300 feet; Sizes: 2" to 42" discharge; Drives: electric and other types from 1 to 1000 h.p.; Type: single stage, double suction, split-case, ball bearing. REQUEST DESCRIPTIVE BULLETIN.

PEERLESS PUMPS

Peerless Vertical Turbine Pumps complement the extensive Peerless Centrifugal Pump line and are adaptable to the widest pumping conditions. Peerless' vertical type pump line includes turbine pumps, propeller and mixed flow pumps, Hi-Lift pumps and domestic water systems for deep or shallow wells. REQUEST BULLETIN.

PLAN WITH PEERLESS

For all your pumping requirements, plan with Peerless. Peerless' comprehensive line of pumps includes Underwriters' approved vertical and horizontal Fire Pumps for plant fire protection, boiler feed and pipe line pumps and scores of vertical and horizontal types with capacities from 10 to 220,000 g.p.m.

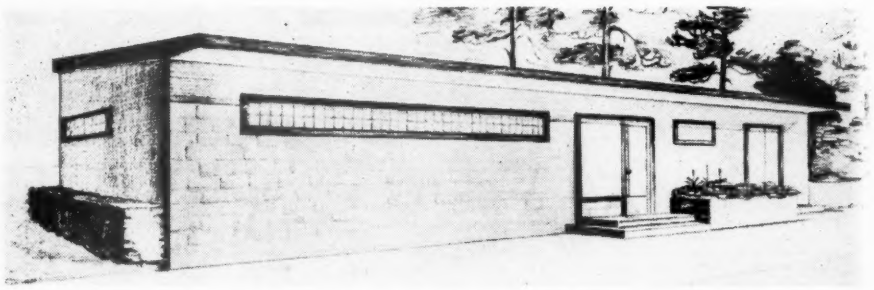
PEERLESS PUMP DIVISION

FOOD MACHINERY CORPORATION

Factories: Los Angeles 31, Calif.; Quincy, Ill.; Indianapolis, Ind.

District Offices: Chicago 40, 4554 No. Broadway. Philadelphia Office: Suburban Square, Ardmore, Pa. Atlanta Office: Rutland Building, Decatur, Georgia; Dallas 1, Texas; Fresno, Calif.; Los Angeles 31, California.

Work begins on new OCT building



Work began recently on a $50,000 engineering and research building for Oil Center Tool Company, it has been announced by John Eckel, vice president in charge of engineering. It is the first step in a $150,000 expansion program for OCT, Eckel pointed out.

The new building will house the engineering department of the company and will include within its 1800 sq ft of production space the latest facilities for research into oil field production problems. Constructed of steel and concrete masonry, it will be of modern industrial design. Precision tools for the manufacture of experimental models of oil field equipment will be installed as soon as the building is completed, which will be in about 45 working days, according to Eckel. Contractors are Kurtz and Lapeyrouse.

"This building will facilitate OCT's program of designing tools to meet the ever-increasing demand in the drilling and production end of the petroleum business for up-to-the-minute tools," Eckel said. "The pressure for improved tools is constantly increasing as the demand for oil increases. Today, wells must be drilled faster and more efficiently."

Returns to Houston

W. B. Whenthoff has returned to Houston and again is in charge of marketing the products of Tube Turns, Inc., in that area. A native of Globe, Arizona, Whenthoff's entire career has been devoted to the sale of industrial supplies and equipment in the West, Southwest, and Mexico.

W. B. Whenthoff

He became associated with Tube Turns, Inc., in 1937, when he opened the firm's Tulsa office. He established Tube Turns' Houston office in 1941.

New service point

The Houston Oil Field Material Company has recently opened a Fishing and Cutting Tool Service Point in Oklahoma City, at 2800 Southeast 29th Street. The opening of this service extension was celebrated with an open house featuring a barbecue, which was attended by drilling personnel in the area.

A complete stock of inside and outside cutters, together with the necessary strings of "little inch" drill pipe and washover pipe, is maintained at this location. Also, spears, overshots, rotary shoes, and all the necessary tools for emergency operations involved in drilling, are available for industry use.

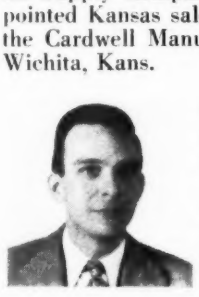
It is also planned to completely equip this store with the directional drilling tools and operators necessary for this type of service in Oklahoma.

Raymond G. Alford is the store manager. Russell Yost, Bob Acuff, and Grover Pool, are operators in the area. Joe Zachary and W. W. Liddell are store men.

The Houston Oil Field Material Company announces the recent opening of additional sales offices in the Fort Worth-Dallas area. W. B. Will, formerly with Homco before World War II, and most recently with Homco's Dallas subsidiary, the Briggs-Weaver Machinery Corporation, has been assigned to assist C. L. (Hal) Roach, who is district sales representative in Fort Worth. Will's office will be 707 Construction Building in Dallas.

Sales representative

Charles Spitzfaden, Jr., formerly machinery sales engineer for the Continental Supply Company, is the newly appointed Kansas sales representative for the Cardwell Manufacturing Company, Wichita, Kans.



Chas. Spitzfaden, Jr.

Spitzfaden joined Continental in 1937 after he was graduated from Washington University, St. Louis, Mo., with a bachelor of science degree in mechanical engineering. He served with the Navy in the civil engineering corps from 1942 until 1946.

After release from active duty as a lieutenant, s. g., he rejoined Continental and last April was appointed assistant district manager for Kansas with offices in Wichita.

District representative

Elmer J. Weis, vice president in charge of sales, Pacific Pumps, Inc., Huntington Park, California, recently announced the appointment of Transmission Engineering Company, 55 Stevenson Street, San Francisco 5, California, as district representative.

CONFIDENCE ... how much is it worth?

IT WAS NINE YEARS before the first gasoline-driven automobile in the United States was operated by C. E. Duryea that the Brooklyn Bridge was opened in 1883. This fabulous engineering achievement was the culmination of over 26 years of planning and building, of bold vision and heart-breaking struggle, by John A. Roebling and his son Washington.

But the steadfast confidence of father and son in the success of their amazing venture is vindicated daily by the modern traffic this world-famous bridge continues to carry now . . . 64 years later.

How much is that confidence worth to you today . . . and to the John A. Roebling's Sons Company, now embarked on a multi-million dollar expansion program to meet the future's challenge?

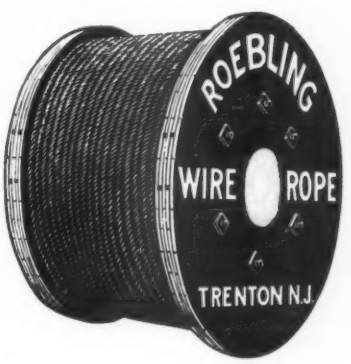
Confidence is the driving power behind our efforts to make better products do better work for you.

You Can't Go Wrong—If You Use the Right "Blue Center" Rope

There's no better way to save wire rope dollars than to use the right rope for your job. That means the right grade of steel, the correct construction, the proper size. And your choice is easy when you specify Roebling "Blue Center" Steel Wire Rope.

In "Blue Center" you get what we feel sure is the finest rope steel made. Secondly, you have a wide range of constructions and sizes to choose from . . . in both preformed and non-preformed types.

Why not make the Roebling Field Engineer your right-hand man in selecting wire rope that will give you peak performance at the lowest overall cost? You can call or write him at our nearest branch office.



The *RIGHT* steel . . .
The *RIGHT* construction . . .
The *RIGHT* size . . .
—FOR YOUR JOB!

JOHN A. ROEBLING'S SONS COMPANY
TRENTON 2, NEW JERSEY

Distributed by: **The National Supply Company—Republic Supply Company**

Manufacturers of Wire Rope and Strand • Fittings • Slings • Screen, Hardware and Industrial Wire Cloth • Aerial Wire Rope Systems • Hard, Annealed or Tempered High and Low Carbon Fine and Specialty Wire, Flat Wire, Cold Rolled Strip and Cold Rolled Spring Steel • Ski Lifts • Electrical Wire and Cable • Suspension Bridges and Cables • Aircord, Aircord Terminals and Air Controls • Lawn Mowers

ROEBLING

A CENTURY OF CONFIDENCE

Oil Base moves to new plant

Oil Base, Inc., has moved its main offices from Los Angeles to its new plant in Compton, California, where all facilities have been combined on a newly acquired 4-½ acre site, for the complete manufacture, packaging, mixing, and shipping of Black Magic oil base drilling fluid.

The plant is strategically situated to ship drilling muds via rail, truck, or water to any oil field in the world.

At present the site is comprised of four buildings. An office building, production and storage plant, a sacking plant (under construction), and a premix plant. When fully equipped, the entire operation will be capable of producing oil base drilling muds, weighting materials, and chemicals for regenerating Black Magic, in volume exceeding $10,000,000 annually, it is stated.

The new 15-room office building is one story, 2800 sq ft, containing a mail room, and modern research and control laboratories.

The main plant is housed in a 12,000 sq ft steel building. New grinding and mixing equipment has been installed as well as conveyors and handling equipment for storing the sacked materials. A quick loading ramp for trucks and trailers has been specially built along one side of the building to expedite loadings.

Under construction is a sacking plant for dry mix where machinery for weighing and filling sacks will be housed. At the south end are nine tanks for premixing Black Magic with a total capacity of 3000 bbl a day. The dry powdered form is mixed with diesel oils for domestic use and delivered pre-mixed in tank cars and trucks to oil wells whose mixing facilities are inadequate. Adjacent to the plant building is a two-acre paved lot where a trucking depot, complete with garage for servicing trucks hauling Oil Base products, will be established.

New magazine

Jones and Laughlin Steel Corporation has distributed to its 42,000 employes and 25,000 shareholders the first issue of the corporation's new monthly magazine *Men and Steel*. The purpose of the publication is to "bring to the attention of employes and shareholders pertinent facts and the views of the management with respect to the past, current and future operations of the Corporation," Admiral Ben Moreell, president, declares in a foreword.

Men and Steel is the first corporation-wide magazine ever published by J & L, although Otis Works, at Cleveland, has been publishing an internal plant magazine called the *Otis Sheet*. *Men and Steel* will replace this as well as several smaller miscellaneous publications that have been put out by different divisions of the corporation.

The magazine is published under the direction of Earl F. Blank, assistant to vice president—personnel and industrial relations of the corporation. Plant editors and their reportorial staff gather and edit the news for the plant sections.

ESTABLISHED 1869

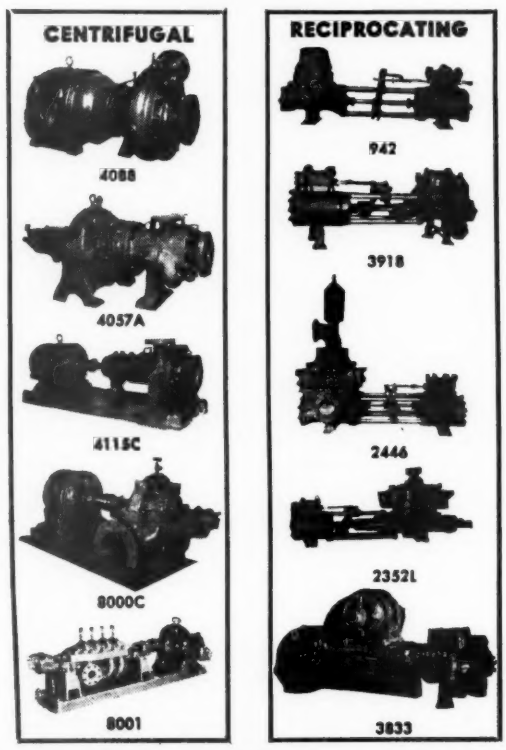
DEAN BROTHERS PUMPS INC.

INDIANAPOLIS IND.

323 W. TENTH ST.

PUMPS

BUILDERS OF OUTSTANDING PUMPS SINCE 1869



BRANCH OFFICES: NEW YORK HOUSTON

Cities Service research program

Centralization and expansion of the extensive research and development activities of Cities Service Company has been announced by W. Alton Jones, president.

First major step in this program, Jones said, is the formation of a new company called the Cities Service Research and Development Corporation, which will be charged with direction of all of the far-flung research activities that have been carried on by individual operating companies of Cities Service for more than 30 years.

The program will cover the entire petroleum field, extending into the realm of plastics, detergents, medicines, paints and lacquers, as well as synthetic fuels. The long-range project is to aid in supplementing the nation's petroleum resources, especially in times of national emergency.

Among major development projects that the new corporation will direct is intensive research, in cooperation with the M. W. Kellogg Company, in the synthesis of liquid petroleum products from natural gas at both the Jersey City, New Jersey, plant of Kellogg, and the Cities Service refinery at Lake Charles, Louisiana. Others include intensifying and centralizing work on the development of automotive and household fuels at the Cities Service refineries at Lake Charles and East Chicago, Indiana; the development of chemicals from natural gas at Tallant, Oklahoma; and the development of lubricants and greases at Ponca City, Oklahoma.

Jones stated that the new corporation also will study the possibility of constructing a new, ultra-modern research laboratory in the New York area as headquarters for the activities of more than 500 Cities Service chemists and scientific workers.

Jones will serve as chairman of the board of the new corporation, A. P. Frame will be president, and C. L. Mateer, vice president.

Mr. Frame will continue in his present position as vice president of Petroleum Advisers, Inc., in charge of all manufacturing operations of Cities Service oil companies.

Lincoln Foundation welding awards

The trustees of The James F. Lincoln Arc Welding Foundation have announced the rules of the Annual Engineering Undergraduate Award and Scholarship Program. This program started in 1942 but was interrupted by the war. Recently upon the advice of the deans of engineering of a number of prominent engineering schools, it was decided that the time had arrived when the program should be resumed.

Dr. E. E. Dreese, chairman of the board of trustees, in making the announcement stated: "The future of engineering rests with the present undergraduate engineering students. The engineering students of today will bring forth the new inventions, designs, and developments of tomorrow.

"In order, therefore, to place these possibilities before the undergraduate engineering student, and to stimulate his imagination, ability, and vision through the study of arc welding in design and maintenance, The James F. Lincoln Arc Welding Foundation sponsors this series of $6750 Annual Engineering Undergraduate Award and Scholarship Programs."

This program contains two interdependent plans: "The Award Plan and the Scholarship Plan. Under the Award Plan, engineering students of various engineering schools and colleges will submit papers on arc welded design and the use of welding in maintenance of machines and structures. Under the Scholarship Plan, scholarships will be allocated to the schools in which the three highest award recipients under the Award Program are registered.

Awards for papers will be as follows:

Number of Awards	Amount of each award	Total amount of awards
1	$1,000	$1,000
1	500	500
1	250	250
4	150	600
8	100	800
12	50	600
50	25	1,250
77		$5,000

The Scholarship Plan is as follows:

The institutions in which the three top awards are made to students will receive amounts of money equal, respectively, to those awards. These amounts are to be used for the purpose of scholarships in the departments in which the award students are registered.

Use of scholarship funds: The department of the institution in which the first award winner is registered will receive $1000 for four annual scholarships of $250 each.

The department of the institution in which the second award winner is registered will receive $500 for two annual scholarships of $250 each.

The department of the institution in which the third award winner is registered will receive $250 for one annual scholarship of $250.

Number of scholarships	Amount of each scholarship	Total amount of scholarship funds
4	$250	$1000
2	250	500
1	250	250
7		$1750

Students' papers are to deal with design for arc welding of parts of machines, complete machines, trusses, girders, structural parts, or their maintenance.

It is not necessary that the machine, structure, or part, be actually built, but the design or method of construction must be described in the paper.

The student need not necessarily adapt arc welded construction to a complete machine or structure but may choose any part of a complete machine or structure, now usually made by other methods, which could be made by this method of construction; or he may conceive of a machine, structure or part which has never but could be built by arc welding.

Resident engineering undergraduate students registered in any school, college or university in the United States, which offers a curriculum in any branch of engineering (including agricultural engineering) or architecture leading to a degree and cadets registered in the United States Military Academy, United States Naval Academy and Coast Guard Academy are eligible to submit papers in this award program.

Copy of the rules and conditions may be obtained by writing The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio.

Open new warehouse

Opening of its new and enlarged wire rope warehouse at Houston, Texas, has been announced by Rochester Ropes, Inc., of Culpeper, Virginia.

E. E. Lambert, southwestern manager, states that the new quarters, at 3115 Polk Avenue, will enable the company to service its distributors and customers from the most complete mill stocks in the entire Mid-Continent area.

Several innovations in wire rope reeling and cutting equipment are being installed that will enable the company to make quicker shipments on large drilling line orders.

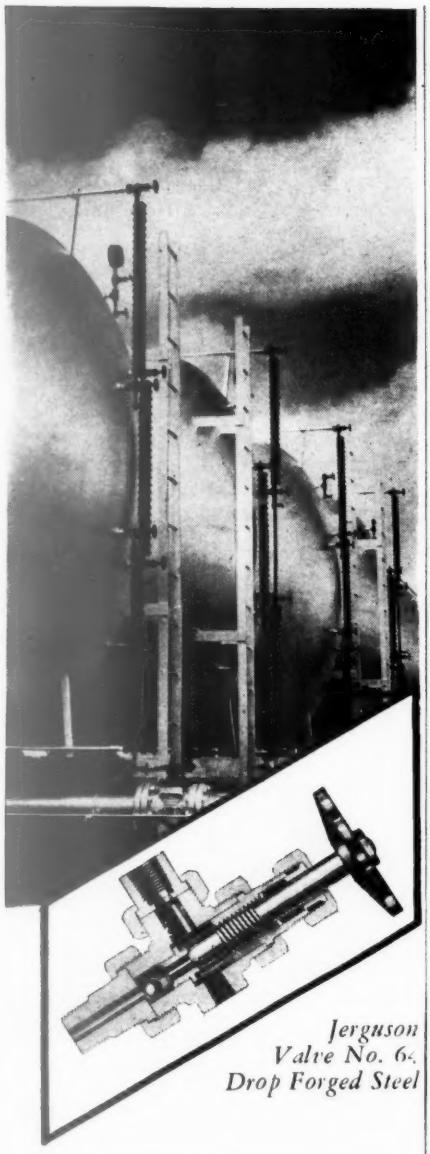
In keeping with its expansion program, Rochester Ropes has installed reeling and cutting machinery in its Odessa warehouse, which is under the direction of Paul Murray.

Rochester Ropes also maintains a mill depot at 29th and Byers Street in Oklahoma City under the direction of J. S Blackman, for service to the Oklahoma-Kansas trade.

Wickwire Spencer sales manager

Newell H. Orr, vice president of The Colorado Fuel and Iron Corporation, announces that H. C. Allington has been appointed general manager of sales of the Wickwire Spencer Steel Division with offices in New York City.

Allington has been engaged in sales work in the eastern area since the close of World War I when he left the service as an army field clerk. As salesman he opened up New England and Upper New York Territory for a well known gasoline pump manufacturer and later became New York and New England district manager for the same company. Several years later, the Sharpsville Boiler Works called him to assume a more important position as eastern district manager. Soon spotted for his ability, the American Machine and Metals, Inc., called him to New York as sales manager of its oil products division and in 1943 Wickwire Spencer Steel weaned him away to manage a new products department but within a few months he was selected assistant general sales manager.



Jerguson Valve No. 64 Drop Forged Steel

FOR EFFICIENCY, USE JERGUSON VALVES, And Flat Glass Gages

JERGUSON No. 64 Gage Valves will do the kind of efficient job you want with flat glass gages.

Distinctive valve design makes it possible to remove the gage *without removing the valves or draining the liquid from the vessel.* This means minimum maintenance time and cost.

Jerguson No. 64 Valves have safety shut-off, stainless steel renewable seats and trim. Recommended for pressures up to 3200 pounds.

Write for Data Unit and full information

JERGUSON GAGE & VALVE COMPANY

100 Fellsway, Somerville 45, Mass.

Representatives in Major Cities
Phone Listed Under JERGUSON

Every parent at some time or another suffers acute embarrassment at some expression uttered by an offspring — that's why we think mammas and papas will appreciate this true story of a small girl. She was doing her homework in arithmetic, and her parents suddenly realized the young 'un was murmuring: "Four and two, son of a b ... , six. Three and five, son of a b ... , eight."

After a pantomine between parents of raised eyebrows and shoulders shrugged in bewilderment, her mother casually asked: "What are you saying, dear?" The little girl said: "Just what the teacher told us, mummy. Seven and three, son of a b ... , ten."

Well, the parents said no more, but the next day the mother dropped in at the school to ask her daughter's teacher what it was all about. After recovering from the initial shock, the teacher thought for a while and then went into spasms of laughter. "I've got it," she said, wiping her eyes. I've been saying to the class: "Four and three, the sum of which is . . ."

* * *

An engineer walked into a fur emporium with a gorgeous blonde on his arm and demanded something expensive to hang on the curvateous creature.

They yanked out something for about $500 and he rejected it with a snarl. "What alley cat did that come from? Bring me something nice."

Next came a $5000 number, then a $10,000, but with each offering his demands grew louder for something better, much better.

So finally, they dug up the key to the vault and brought forth a coat worth about $2 less than a king's ransom.

"Now that's fine," said the engineer, as his companion stared goggle-eyed at the creation. "Here's my check. You investigate at my bank to make sure it is good and I will be back Monday for the coat."

But Monday when he returned, he found the store manager in a purple passion. "You fraud! You cheat! The bank never heard of you! If you want that coat you'll have to pay for it in cold cash."

"Oh, I didn't come after the coat," said our hero: "I came to thank you for a wonderful weekend."

* * *

The laziest man in California stands with a cocktail shaker in his hand and waits for an earthquake.

* * *

It was during the start of the Lenten Season. Pat's wife was telling him that Finnegan gave up smoking and O'Toole gave up drinking. So she asked Pat if he'd sleep in one room during Lent and she in another. Pat agreed.

A week later, Pat's wife was knocking at the door of his room one night. Pat asked gruffly, "Who is it, and what do you want?"

Pat's wife said, "It's me and I came to tell you Finnegan started smoking again today."

* * *

A businesswoman entertaining some businessmen at luncheon in a French restaurant, and not wishing to be obvious about paying the check, whispered to her waiter when the meal was over, "L'addition, s'ily vous plait."

"Downstairs to your left, lady," he said.

* * *

An evangelist recently announced there are 727 sins. We understand he is getting requests for the list from people who think they must be missing something.

* * *

ENGINEERING PROBLEM

A cross-eyed woodpecker with a cork leg and a synthetic rubber bill requires 4½ hours to peck ¾ of the distance through a cypress log 53 years old. Shingles cost $.79 per hundred and weigh 8 ounces apiece. The log being pecked upon is 34 feet long and weighs 47 pounds per foot. Assuming that the coeffiecient of friction between the woodpecker's bill and the cypress log is .097, and that there is a negligible resistance to diffusion, how many units of vitamin B-1 will the woodpecker require in pecking out enough shingles for a $7500 barn with a detachable chicken house? The woodpecker has an efficiency of 97 per cent and gets time and a half for overtime.—Submitted by J. S. Leonard, superintendent, The Ohio Oil Company, Knox City, Texas.

* * *

A businessman visited his banker and asked: "Are you worried about whether I can meet my note next month?"

"Yes, I am," confessed the banker.

"Good," said the client. "That's what I'm paying you six per cent for."

* * *

Two travelers in Ireland, returning home late one night, lost their way.

Said one, "We must be in a cemetery. Here's the gravestone."

"Whose is it?" asked the other.

The more sober of the two, having struck a match, said "I don't know but he seems to have lived to a ripe old age—175."

"Can you read the name?" insisted his companion.

Another match having been lit: "I don't know him. Some fellow called 'Miles from Dublin'."

ARE THESE THE QUESTIONS you would ask about any packer?

CAN IT BE DRILLED UP EASILY? The Baker Retainer Production Packer is completely drillable. You will never have to "mill up" a Baker Packer.

DOES IT RESIST CORROSION? Yes, the cast iron construction of the Baker Packer is far more resistant to corrosion than the steel casing in which it is set.

IS THE PACKER INSTALLED AS PART OF THE TUBING STRING? Not the Baker Retainer Production Packer which virtually becomes a part of the casing when it is set. The tubing can be pulled and run-in again as often as is necessary.

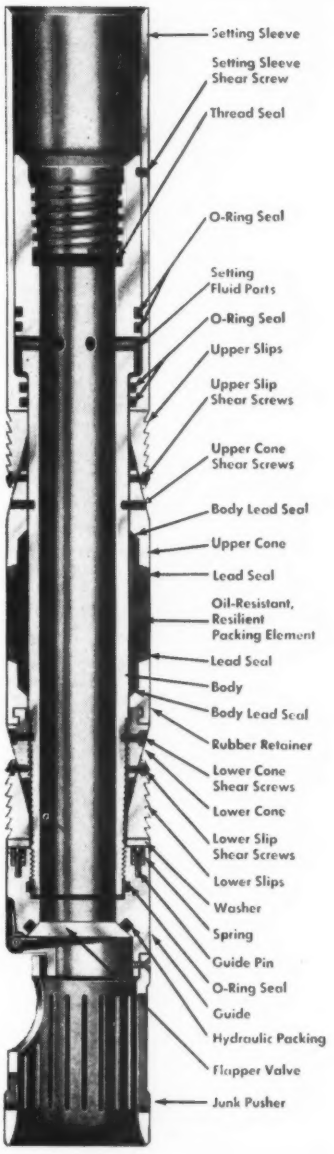
DOES IT HOLD BOTH WAYS? Yes; Baker Packers are anchored against either upward or downward movement by two full sets of opposing slips.

DOES IT REQUIRE "SET-DOWN" WEIGHT? When it is desirable, the tubing can be suspended in tension, thus eliminating the possibility of "corkscrewed" tubing which would hinder or prevent dropping pressure bombs, or other similar operations.

DO YOU HAVE TO REMOVE THE PACKER TO GUN-PERFORATE OR CLEAN OUT BELOW IT? Not the Baker Retainer Production Packer, which is equipped with a positive-sealing, flapper type back-pressure valve. This flapper valve opens readily to permit the downward passage of tubing or tools, but closes instantly to hold safely against back-pressure when the tubing (or tools) are being removed from the well.

IS IT ADAPTABLE TO SEVERAL APPLICATIONS? Yes; to practically all applications, and to all operating procedures. Single-zone or two-zone hook-ups are possible to meet any production requirement. The Baker Retainer Production Packer also is ideal for water-injection or flooding re-pressuring, re-cycling, testing, acidizing, gas-lift, and many other applications.

WHO MAKES THIS PACKER, AND HOW CAN I GET MORE INFORMATION ABOUT IT? The Baker Retainer Production Packer (Product No. 415-D) is made by Baker Oil Tools, Inc., and Baker representatives are stationed in all active areas to give you prompt and intelligent service. Get in touch with your nearest Baker man today.



Baker Retainer Production Packer Product No. 415-D

BAKER OIL TOOLS, INC.
Houston • Los Angeles • New York

BAKER
RETAINER PRODUCTION
PACKER

running tour with men in the industry

● **Frank D. St. Hilaire** recently joined The Lummus Company, New York, in the capacity of inspection coordinator heading up a group of refinery equipment inspectors throughout the country and reporting to E. I. Lummus. Previously, he was connected with the foreign operations department of The Texas Company handling engineering service in Latin America. For seven years he was with Trindad Leaseholds Limited, Trinidad, British West Indies, as assistant plant superintendent of its topping and re-run division. His present headquarters are in Graybar Building, New York City.

F. D. St. Hilaire

● **John M. Campbell** has recently been appointed to the Gulf Oil Corporation Fellowship that was established in the School of Chemical Engineering at the University of Oklahoma in July, 1947. Campbell graduated from Iowa State University in 1943. During the war he was connected with the Du Pont Company in Cleveland, Ohio, and Hanford, Washington. He is now an instructor in the School of Chemical Engineering and is also working toward a master's degree in chemical engineering.

● **Dr. Newcomb K. Chaney,** for the last 12 years director of research for The United Gas Improvement Company, Philadelphia, has been appointed to direct the gas production research program of the American Gas Association. Dr. Chaney takes charge of the work previously directed by **Edwin L. Hall** who has been appointed director of the association's testing laboratories at Cleveland and Los Angeles.

● **James Tanham,** vice president of The Texas Company, with headquarters in New York, sailed recently aboard the S. S. Yarmouth for Havana, Cuba, to represent the International Organization of Industrial Employers at the United Nations Conference on Trade and Employment.

● **H. E. Bramston-Cook** has been appointed to the newly created position of general manager, eastern operations, of Oronite Chemical Company of San Francisco, a Standard of California subsidiary. He has been general sales manager for the company for the past year.

Bramston-Cook will supervise both sales and product development work for Oronite east of the Rockies, and of foreign operations. His headquarters will be at the company offices in New York. He joined Oronite in October, 1946, and is widely known in the chemical and oil industries for his accomplishments in manufacturing, research, and sales.

● **W. Henry Linton** has been named assistant to Clarence H. Thayer, vice president in charge of manufacturing, Sun Oil Company. Linton, former manager of the refinery accounting department will serve as an administrative assistant. Linton joined Sun Shipbuilding and Dry Dock Company, wholly owned subsidiary of Sun Oil Company, as a clerk in the accounting department in 1919 shortly after his graduation from Chester High School. Three years later he entered the accounting department of Sun Oil Company at Philadelphia. In 1926 he was placed in charge of the yield department at Sun's Marcus Hook refinery, continuing in that capacity until 1931 when he returned to the Philadelphia office. From 1937 to 1942 Linton served as office manager and chief accountant at Marcus Hook. Recalled to the company's main office in 1942, he was appointed manager of the refinery accounting department.

● **Thomas H. Pike, Jr.,** assistant sales manager of the Welding Fittings Division of Tube Turns, Inc., Louisville, Kentucky, has announced two promotions. **Norton P. Bosemer** has been placed in charge of the Los Angeles office, at 1489

N. P. Bosemer

R. S. Tyler

Washington Boulevard, and **Robert S. Tyler, Jr.,** has been placed in charge of a newly established Mid-Continent district, with headquarters at 311 Tuloma Building, Tulsa. Bosemer joined Tube Turns sales staff in April, 1937, and was assigned to the San Francisco office in May, 1944. Tyler became associated with Tube Turns, Inc. in January, 1946, after four years of service with the Navy, and is a graduate of Tube Turns' sales training project.

● **Storrs J. Case** has been named advertising manager of Sun Oil Company. Case, a native of Detroit, has been in advertising or sales promotion in the automotive field for 24 years. Until recently he owned and operated a tire distributorship at Van Nuys, California.

In his new position, he will direct all Sun Oil Company's advertising. Fred S. Cannan will act as assistant manager in charge of motor products advertising, and Laurens H. Fritz as assistant manager in charge of industrial products advertising.

● **J. H. Dunn,** president of The Shamrock Oil and Gas Corporation, announces that **Ray C. Johnson** has been elected vice president and general counsel of the corporation, and **F. V. Wallace** and **B. E. Tyler, Jr.,** have been elected secretary and treasurer, respectively. In making the announcement Dunn stated, "Mr. Johnson, who also will continue to serve as a director of the corporation, has been closely connected with the company since its organization as attorney and in more recent years as secretary-treasurer and a member of the board of directors. While we have had the benefit of Mr. Johnson's counsel and advice for many years, we feel that we will benefit the more from his willingness to devote his entire time in Shamrock's behalf." In making the announcement, Dunn explained that the election by the directors of Wallace and Tyler was in keeping with the general policy of the company to promote those within the organization to positions of higher responsibility when possible. Wallace has been employed by the company in numerous positions for 13 years, and Tyler has been with the company for 10 years as auditor in the general offices of the company at Amarillo.

● **Charles E. Weeks** has been made assistant to the operating vice president of Southern Alkali Corporation, Corpus Christi, Texas, it has been announced by O. N. Stevens, operating vice president for the firm. A native of Runge, Texas, Weeks has been associated with Southern Alkali since the firm was established here in 1934. Prior to this appointment, he had served as auditor for the alkali producing firm. His headquarters will be at the Southern Alkali plant, Corpus Christi.

● **Jack Skeehan,** formerly with Spang-Chalfant Company, Houston, Texas, and Los Angeles, California, has joined Thornhill-Craver Company. Skeehan is the Unibolt field representative in the Pacific Coast area with headquarters in Los Angeles.

Jack Skeehan

● **G. A. Tompson,** vice president of Bethlehem Supply Company, attended the annual API convention in Chicago the week of November 10. Other personnel of the Bethlehem Supply Company attending the convention were: H. R. Powers, assistant sales manager; B. E. Groenewold, manager of engineering sales; T. B. Leech, manager of refinery sales; J. F. Eaton, Tulsa plant manager; H. E. Davidson, Tulsa plant engineer; I. C. Smith, Corsicana plant manager, and Lee Fag, Corsicana plant engineer.

10 GOOD REASONS WHY OPERATORS PREFER

10 This is a section of a McCullough 90-SHOT GUN perforating a 15-foot section with 6 holes to the foot, at one run.
GUN PERFORATOR

McCullough
GUN PERFORATOR SERVICE

1. **MEETS EVERY CONDITION.** Guns fired either electrically or mechanically: guns run on cable, sand line, drill pipe, tubing, or on piano-wire measuring line in extremely high-pressure wells.
2. **SIMULTANEOUS FIRING** under all conditions gives exact spacing of shots, perfect perforation pattern, and saves down-the-hole time.
3. **ACCURATE DEPTH MEASUREMENTS** put the shots right where you order them.
4. **MAXIMUM PENETRATION** of bullets into the formation, as proved repeatedly in competitive field tests.
5. **GUNS TO FIT EVERY CONDITION.** McCullough employs more than 30 different types and sizes of guns.
6. **ALL SIZES OF BULLETS** from ⅛" dia. up to ¾" dia., to fit every possible need.
7. **BURRLESS BULLETS,** giving a completely burr-free hole, eliminating casing scraping, with *no* sacrifice of penetration.
8. **NO LOST TIME.** McCullough's simpler, lighter equipment cuts setting-up and moving-out time, speeds up every job.
9. **EXPERIENCED MEN.** With years of experience behind them, thoroughly-trained McCullough gun-perforating crews do their jobs quickly, efficiently, safely.

These Are Some of the Reasons Behind the Proven Fact That

McCullough

PUTS THE SHOTS WHERE THEY COUNT

McCullough TOOL COMPANY

5820 South Alameda St., Los Angeles 11, California
405 McCarty Avenue, (P. O. Box 2575) Houston, Texas

24 SERVICE LOCATIONS

TEXAS:	Victoria	**MISSISSIPPI:**	**CALIFORNIA:**	**LOUISIANA:**
Houston	Wichita Falls	Laurel	Los Angeles	Houma
Alice	**OKLAHOMA:**	**NEW MEXICO:**	Avenal	Lake Charles
Corpus Christi	Oklahoma City	Hobbs	Bakersfield	New Iberia
McAllen	Guymon	**KANSAS:**	Sacramento	Shreveport
Odessa	Healdton	Ulysses	Ventura	**WYOMING:**
Tyler				Casper

EXPORT OFFICE: 30 Rockefeller Plaza, New York 20, N. Y.

CLOGGED FILTER SCREENS ... cleaned easily!

PROBLEM: To remove crude oil residue from obstructed filter mesh. To restore filter screens to efficient operation.

SOLUTION: Soak screens in recommended Oakite degreasing solution. Then rinse screens and immerse them in Oakite acidic detergent solution. Neutralize. Thoroughly rinse.

RESULTS: Built-for-the-job Oakite materials provide speedy complete removal of grease, sand, dirt, tar and other impeding deposits. Screens come out in excellent shape ... ready for reuse. Full filtering capacity restored—thanks to safe, thorough Oakite cleaning.

Technical Data Free

Full details for filter cleaning are yours free in the Oakite "88" Digest. Send for your copy today. It not only outlines filter cleaning methods but 87 other commonly performed maintenance jobs where Oakite materials and methods can help save you money.

OAKITE PRODUCTS, INC.
42 Thames Street, NEW YORK 6, N. Y.
Technical Representatives in Principal Cities of U. S. & Canada

OAKITE

Specialized Industrial Cleaning
MATERIALS • METHODS • SERVICE

● **Bart W. Gillespie,** project manager for Arctic Contractors at Fairbanks, Alaska, attended the recent annual meeting of the operating committee of the Director of Naval Petroleum Reserves at Washington, D. C. After the meeting, he spent a few days visiting drilling and producing operations in South Louisiana and Mississippi as a guest of friends with the Humble Oil and Refining Company at New Orleans. He visited some other friends at Dallas before flying to Los Angeles and on to Fairbanks, where he will continue his work in connection with the Navy's search for oil in Northern Alaska.

● **T. Norman Willcox** has been made manager of the methods and equipment laboratory of the plastics division of the General Electric chemical department. Willcox, who has been section engineer of the methods and equipment laboratory since last February, joined the company in 1936 as a member of the student test course. Joining the plastics division at Pittsfield in 1938, he was assigned to the engineering section and followed closely the development of G-E mycalex molding. In 1942 he was transferred to the Taunton Works as a product engineer and the following year was brought back to Pittsfield as a development engineer in the methods and equipment laboratory.

● **Roy N. Bean,** educated at the University of Oklahoma and registered mechanical engineer in the State of Texas, announces opening of offices at 800 East Ocean Boulevard, Long Beach 2, California. Here he will officiate as manufacturers' agent for the following accounts: Oil Center Tool Company, The Southwest Company, Oil Tool Manufacturing Company, and Universal Packing and Gasket Company, all of Houston, Texas. Before launching out on his own, Bean had spent 11 years with Cameron Iron Works, mostly as development engineer, and had been responsible for some very effective and important equipment items.

Roy N. Bean

He has had a wide experience in various types of field service, for such firms as Continental Supply Company, D+B Division of Emsco, Halliburton Oil Producing, and Halliburton Oil Well Cementing companies. He was for a time sales manager for J. H. McEvoy and Company (now McEvoy Company) and had some service with Layne and Bowler. Immediately upon graduation from college, he began devoting himself to oilfield engineering, and through actual participation garnered also an insight into the business of contract oilwell drilling. He was instrumental in opening the Pacific Coast branch of Cameron Iron Works in 1939 and 1940, so is no stranger to the local fields.

● **John W. Boatwright** has been appointed general manager of the distribution economics department of Standard Oil Company (Indiana). He formerly headed the combined sales research and budgeting departments. In his new position he will be responsible for all functions relating to sales budgets, general economic studies, problems of product supply, consumer research studies, economic evaluation studies, and profit and loss analyses previously performed in the sales research and coordinating departments.

D. S. Warning has been appointed manager of the commercial research division of the distribution economics department, with responsibility for sales budgets, general economic studies, problems of product supplies, and consumer and sales research reports.

R. M. Eberly has been appointed manager of the coordinating division of the distribution economics department. He will be responsible for economic studies pertaining to manufacturing and transportation problems, and sales department expense and profit analyses.

● **Jack Podlech** has been appointed assistant to the president and counsel of Oil Base, Inc., Compton, California. Podlech, a member of the California Bar Assocation, was previously with Richfield Oil Company in the land and lease department, and with the trust division of Citizen's National Bank of Los Angeles. He is a graduate from the University of Southern California and served in the Navy during the war. Podlech will head up the newly formed legal department at Oil Base, Inc., under the supervision of George Miller, president.

Jack Podlech

● **L. N. Harrison,** southeastern district manager of the Votator Division of The Girdler Corporation, has moved his headquarters from Charlotte, North Carolina, to 505 Forsyth Building, Atlanta, Georgia.

● **Eldon Young** and **Archie D. Gray** have been appointed general attorney and associate general attorney, respectively, of Gulf Oil Corporation and Gulf Refining Company with headquarters in Houston, Texas.

● **Dr. Robert L. Smith** has been appointed to supervision of the project evaluation division of Sinclair's Research and Development Department at East Chicago. The assignment was made in conjunction with the scheduled expansion of research activities to be carried out at the new laboratories in Harvey, Illinois. For the last 15 months Dr. Smith has been engaged in process development with Sinclair research. His new position involves planning of research programs, project evaluation, data correlation, and development of design methods. Assisting him will be **Harry Mayland.**

● **Lloyd A. Harris,** diesel engine specialist, has been transferred from the National Supply Company's Superior Engine Division, Springfield, Ohio, to the Plant Products Division. Harris will represent National Supply in the sales and service of Superior engines in all branches of the oil industry, and has already assumed his new duties with headquarters in Houston, Texas.

Lloyd A. Harris

A veteran of the oil field country, Harris was associated with Waukesha Motor Company, Tulsa, Oklahoma, prior to his joining the Superior Engine Division of National Supply in 1942. For the last two years he has represented the company in both oil field and municipal sales in Houston, New Orleans, and Fort Worth.

● **Robert W. Pack** has been appointed director of production of Sun Oil Company. Pack, formerly general manager of the company's Gulf Coast division, will move his headquarters from Beaumont, Texas, to Philadelphia about January 1. He has been a member of the company's board of directors since last March.

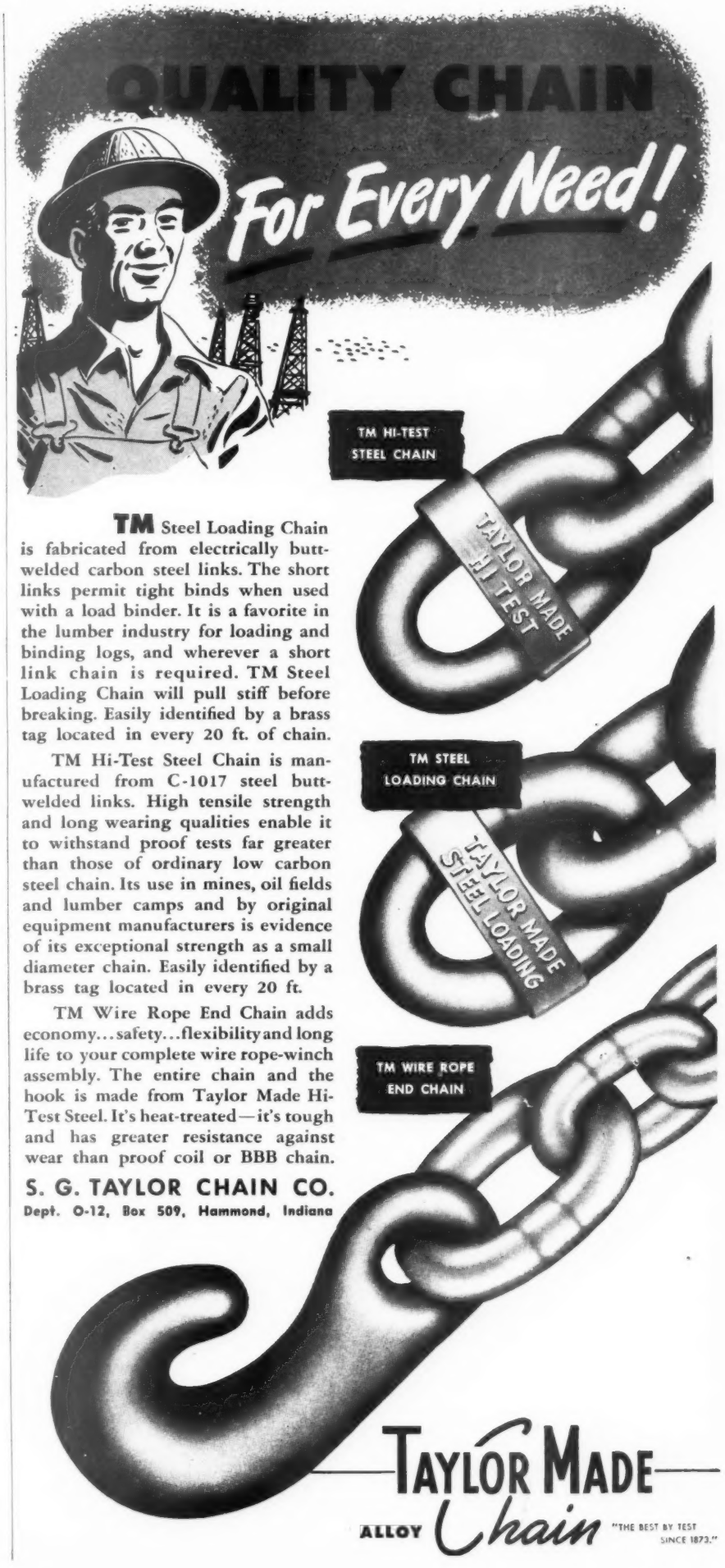
Simultaneously, Jno. G. Pew, vice president in charge of production, announced the creation of a three-member management committee to succeed Pack in the Gulf Coast division. The members are: P. S. Justice, head of land and geological operations; Donelson Caffery, manager of supply and transportation, and Joiner Cartwright, general counsel. All have headquarters in Beaumont.

● **F. H. Paul,** who has been assistant treasurer of California Texas Oil Company, Ltd., since Caltex was founded in 1936, has been elected treasurer of the company. Paul has been in the treasury department of Caltex and affiliated companies since 1922.

● **Douglas Orme** has been elected vice president in charge of traffic of the Cosden Petroleum Corporation. Orme joined Cosden May 1, 1929, and has served in the traffic department since that time. He was promoted to traffic manager in December 1935.

● **J. Elston Ahlberg** has joined the research staff of the Davison Chemical Corporation, Baltimore, Maryland. Dr. Ahlberg is well known in the oil industry for his work in the development of methods of manufacturing cracking catalysts. During the last 11 years he was associated with the Universal Oil Products Company, Chicago, Illinois.

● **H. L. Hawkinson, Jr.,** was promoted November 1 to local representative for machinery sales in the Houston sales office of the Bethlehem Supply Company. Hawkinson, formerly field representative at Odessa, Texas, has been employed by the company 6½ years. He is a graduate of Oklahoma University and served four years in the armed forces during the war.

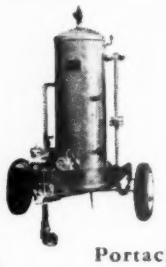

QUALITY CHAIN
For Every Need!
TM HI-TEST STEEL CHAIN
TAYLOR MADE HI TEST
TM STEEL LOADING CHAIN
TAYLOR MADE STEEL LOADING
TM WIRE ROPE END CHAIN
TM Steel Loading Chain is fabricated from electrically butt-welded carbon steel links. The short links permit tight binds when used with a load binder. It is a favorite in the lumber industry for loading and binding logs, and wherever a short link chain is required. TM Steel Loading Chain will pull stiff before breaking. Easily identified by a brass tag located in every 20 ft. of chain.
TM Hi-Test Steel Chain is manufactured from C-1017 steel butt-welded links. High tensile strength and long wearing qualities enable it to withstand proof tests far greater than those of ordinary low carbon steel chain. Its use in mines, oil fields and lumber camps and by original equipment manufacturers is evidence of its exceptional strength as a small diameter chain. Easily identified by a brass tag located in every 20 ft.
TM Wire Rope End Chain adds economy...safety...flexibility and long life to your complete wire rope-winch assembly. The entire chain and the hook is made from Taylor Made Hi-Test Steel. It's heat-treated—it's tough and has greater resistance against wear than proof coil or BBB chain.
S. G. TAYLOR CHAIN CO.
Dept. O-12, Box 509, Hammond, Indiana
TAYLOR MADE ALLOY Chain
"THE BEST BY TEST SINCE 1873."

The Bowser Automatic Well-Check System furnishes an accurate, indisputable record of individual well production *quantity* and *quality*—puts each well on its own merits . . .

- Eliminates gauge tanks
- Stops evaporation losses
- Reduces pumping and transportation costs
- Minimizes fire hazards
- Furnishes true proportional sample
- Provides permanent, indisputable records
- Accurately records gross production
- Detects sleepers or wet wells

ENGINEERED TO HANDLE ANY TYPE OF OIL WELL PRODUCTION WITH THESE PROVED WELL-CHECK UNITS

1. Bowser Special Oil Well Xacto Meter—no metal-to-metal contact—VERTICAL PISTON operation for sustained accuracy and long life.
2. Bowser True Proportional Sampler.
3. Bowser SPILL-PROOF GAS TRAP with patented Peel-Off Valve—no packing glands—no valves to grind or adjust.



Portachek—the portable Bowser Well-Check Unit—is used to test the potential production of new wells before installing permanent Bowser Well-Check Systems.

BOWSER ESTABLISHED 1885

Write for complete information on Bowser equipment for modern oil fields.

BOWSER, Inc.

1329 Creighton Avenue, Fort Wayne 2, Indiana

LIQUID CONTROL SPECIALISTS SINCE 1885

● **William H. "Bill" Keffer,** 63 years old, vice president and director of the Ashland Oil and Refining Company, died November 17 in the King's Daughters' hospital, Ashland, Kentucky, following a heart attack. He had been ill for several days. Keffer was widely known in the oil industry, in which he had spent most of his life, and at the time of his death was in charge of pipe lines and crude oil production for the Ashland Oil and Refining Company. He was also president of the Owensboro-Ashland Company, a director of the Third National Bank of Ashland, and a director of the Kentucky Oil and Gas Association.

● **Robert J. Crawford** has been promoted from assistant manager to manager of the refinery-accounting department of Sun Oil Company. Crawford succeeds **W. Henry Linton** whose appointment as assistant to the vice president in charge of manufacturing was announced recently.

● **B. H. C. Stover,** Columbia, Mississippi, chief clerk of the Hub district, has been transferred to the Grand Isle district, Harvey, Louisiana, as district chief clerk, by Humble Oil and Refining Company's Production Department.

J. D. Cole, chief clerk of the Paradis district, Paradis, Louisiana, replaces Stover.

O. J. Aucoin, district chief clerk for the North Crowley district, Crowley, Louisiana, has been transferred to the Paradis district as chief clerk.

Jack Pierce, assistant district chief clerk for the Bayou sale district, Franklin, Louisiana, has been transferred to the North Crowley district and promoted to district chief clerk.

C. C. Pyle, assistant district chief clerk of the North Crowley ditrict, has been transferred to the Bayou Sale district as assistant district chief clerk.

F. G. Henry, Hawkins district chief clerk, Hawkins, Texas, has been transferred to the North Crowley district and promoted to assistant district chief clerk.

Ollie Canion, general clerk, has been transferred from the civil engineering division in the Houston office to the Grand Isle district, Harvey, Louisiana, as assistant district chief clerk.

G. W. Jones, assistant chief clerk, was transferred from the Houston trucking terminal to the material section of the production operating department, Houston.

● **R. W. Hamlet** has retired as an assistant treasurer of Socony-Vacuum Oil Company, Inc., after more than 37 years' service with the company. **George F. Molter,** who has been with the company since 1934, has been elected an assistant treasurer.

● **George W. Robey,** former sheriff of Coleman County, Texas, has been added to the staff of the Texas Mid-Continent Oil and Gas Association, Charles E. Simons, vice president and general manager, announces. Robey joins John W. Kelley, veteran special investigator and former Breckenridge chief of police, in the association's theft prevention campaign against thieves who menace oil company supplies and equipment.

● **H. Bloemgarten,** vice president of exploration and production of Shell Oil Company, Inc., has been appointed managing director in charge of the technical operations of the Royal Dutch Shell Companies, effective January 1. His headquarters will be at The Hague. Bloemgarten has been with the Shell organization more than 25 years. In 1935 he was appointed vice president in charge of production in St. Louis. Since 1942 he has made his headquarters in New York.

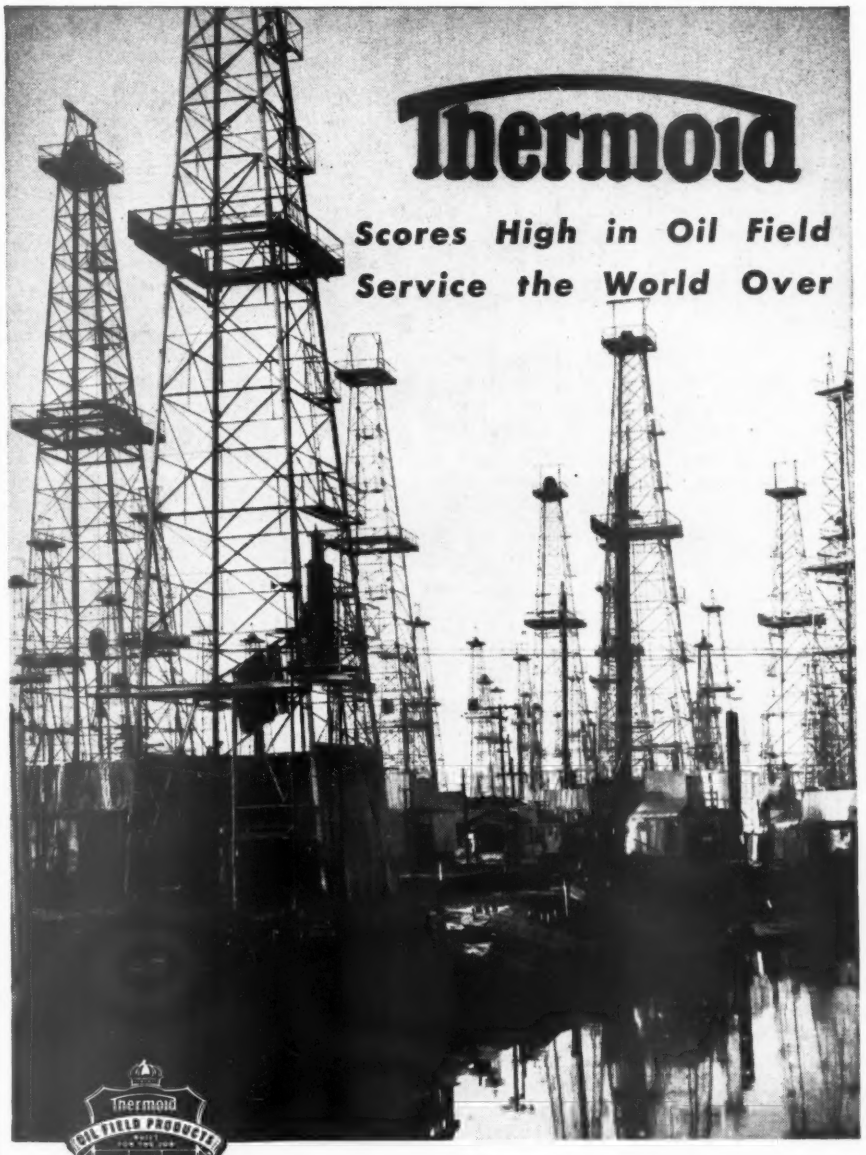
H. S. M. Burns, president of Shell Oil Company, Inc., announced that **A. J. Galloway,** regional vice president of Shell in Houston, has been appointed vice president in charge of exploration and production, replacing Bloemgarten. Galloway joined Shell in June, 1926, as an assistant geologist in California. He moved rapidly through positions of increasing responsibility, and in 1934 was made vice president of the Shell Petroleum Corporation in St. Louis. He retained the position through 1939. When Shell Petroleum was consolidated with Shell Oil Company, Inc., Galloway moved to Houston in September, 1940, becoming regional vice president of the Texas-Gulf and Mid-Continent areas.

E. D. Cumming, manager of Shell's American department in London, will succeed Galloway in Houston, Burns said. Cumming graduated in engineering from Auburn University, Alabama, and was first employed by Shell at Long Beach, California. He spent the early part of his career in technical positions with the company on the Pacific Coast. He has served as both technical assistant and manager of Shell refineries at Wilmington and Martinez, California. In 1938 he became manager of Shell's Wood River, Illinois, refinery, and in 1939 vice president in charge of manufacturing. On special leave of absence during the war, he served as director of refining for the Petroleum Administration for War. He was made vice president in charge of exploration and production of the Pacific Coast area October 1, 1944. Remaining in that position until October 31, 1946, when he went into Shell service overseas.

● **George E. Reese** has been appointed chief chemist at Sun Oil Company's Marcus Hook refinery. He succeeds Edward M. Hughes, chief chemist since 1919, who has been appointed to the newly-created position of consultant chemist.

He joined Sun as a refinery laboratory chemist in 1924 after graduating from Gettysburg College. **Theodore R. McClure** will succeed Reese as assistant chief chemist.

● **W. M. Hall** has been elected a director of the Creole Petroleum Corporation to fill the vacancy left by the resignation of L. F. McCollum, who is now president of the Continental Oil Company. Hall has been associated with the Standard Oil Company (N. J.) and its affiliated interests since January, 1921, when he joined the company as a rig builder. After serving in various foreign assignments for a little more than 22 years, he was transferred to New York to join the foreign producing department of the Standard Oil Company (N. J.)



There are common sense reasons why Thermoid's complete line of rubber products and friction materials for Oil Field equipment sees service in all parts of the world . . . wherever oil is handled.

There is a definite economy and convenience to the buyer—since a single source of supply furnishes the entire line.

There is the assurance that high quality standards are rigidly maintained in products sold under the Thermoid trade mark. And finally—there is a convenient warehousing and shipping set-up that saves precious time when articles are needed in a hurry.

Thermoid serves the world-wide Oil Industry with the products listed below.

Rotary Brake Blocks • Woven Oil Field Brake Lining • Drill Pipe Protectors • V-Belts and Drives • "No Wip" Line Saver • "Powerflex" Pressure Seal Rotary Hose • Slush Pump Hose • Oil Country Belting • Stuffing Box Rings • Wire Line Turn Back • Flexible Discharge Unit Hose • All Types of Production Hose • Tubing Protectors

Thermoid Products

Automotive • Industrial
Oil Field • Textile

Thermoid Company, Trenton, N. J., U. S. A.

Warehouses in Houston, Los Angeles, Wabash

Purchases firm

Johns-Manville Corporation has announced the purchase of Van Cleef Bros., Inc., of Chicago, internationally known manufacturers of "Dutch Brand" industrial and automotive products. Financial details of the transaction were not made public.

The announcement was made jointly by Lewis H. Brown, chairman of the board, Johns-Manville Corporation, and Noah Van Cleef, president, Van Cleef Bros., Inc.

The Chicago firm will be operated as a wholly owned subsidiary of Johns-Manville Corporation. No change is being made in the manufacturing, merchandising, or distribution system of Van Cleef Bros., Inc.

25-year club grows

Membership of The Twenty-Five Year Club of the Spang-Chalfant Division, National Supply Company, of Ambridge, Pennsylvania, climbed to 138 on Saturday night, November 22, with the induction of a new group of 22 employes who have just completed a quarter of a century of service with the division.

A. E. Walker, president of National Supply Company, presented the new members with gold pins bearing the company's insignia and set with five diamonds, each symbolic of five years of service, at the club's fourth annual party held in the Ambridge Country Club. Walker also awarded pins set with six diamonds to 32 other employes who have completed 30 or more years of service.

Michael J. Smith, who started with the company as a plugman in 1922 and now is sizing mill operator, made the acceptance speech in behalf of the new members. Mark P. Prus responded for the 30-year men.

C. R. Barton, vice president in charge of manufacturing, and former Ambridge plant manager with 29 years of service, was the principal speaker. H. J. Litsey, general superintendent at Ambridge with 30 years of service, was toastmaster.

ARCCO
MACNICK
UNIVERSAL
CHART
CLOCK
10 ROTATION SPEEDS
Converter gears requiring no tools to install, changes the clock from 24 hour rotation to any one of 10 different chart rotation speeds. Adapters are available to fit the Arcco Macnick Chart Clock to practically every make of recording guage.
Hermetically Sealed
The clock has been engineered to insure accurate operation under all field conditions. The case, made in two parts, is joined and hermetically sealed by a tightly fitting neoprene gasket of special design which protects against moisture, dust or corrosive gases. Price $10.50 fob Los Angeles or Tulsa.
Send for Bulletin No. 104-A
AMERICAN
RECORDING CHART CO.
3113 E. 11th Street · Los Angeles 23, California
SEND FOR BULLETIN No. 104-A

Heads sales office

Link-Belt Company announces that, in order to more directly serve customers in western portion of the lower peninsula of Michigan, it has established its own sales office in Grand Rapids, Michigan, with headquarters at 406-407 Murray Building, 48 Division Street, North, postal zone 2. Peter Groustra, formerly district sales engineer at Detroit, has been appointed district sales manager in charge of the new office.

Peter Groustra

Groustra entered the company's employ in 1926 in the capacity of a draftsman at the Pershing Road plant in Chicago. In his new position, he will be assisted by Herbert E. Wolf, who has been a member of the staff of the Link-Belt Ewart plant in Indianapolis since 1934.

Trip to States

Elmer R. Smith, sales and service engineer for the H. C. Smith Oil Tool Company throughout South America, has returned from a two-month trip to the United States. Previously making his headquarters at Bogota, Colombia, he has just moved his offices to Caracas, Venezuela.

E. R. Smith

New managers

The Oceco Division of The Johnston and Jennings Company, manufacturers of vapor conservation and fire prevention equipment for storage tanks, has announced the transfer of J. R. Edwards Sr., formerly Pittsburgh manager, to be manager of the New York district, succeeding George T. Bloom who has resigned after 25 years of service.

J. R. Edwards, Jr., who has been assistant in Pittsburgh, advances to manager of the Pittsburgh district. Del Heideman, development engineer, has been transferred from Cleveland to New York as office manager. All appointments became effective December 1.

the Petroleum Engineer's CONTINUOUS TABLES

a daily reference for operating men

INSTALLMENT No. 126

A valuable and regular feature of *The Petroleum Engineer*, the Continuous Tables, now in their eleventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer*. Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have been developed as a result of suggestions for new tables, direct contributions and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue; 98-100, inclusive, in the October, 1945, issue; 101-103, inclusive, in the January, 1946, issue; 104-106, inclusive, in the April, 1946, issue; 107-109, inclusive, in the July, 1946, issue; 110-112, inclusive, in the October, 1946, issue; 113-115, inclusive, in the January, 1947, issue; 116-118, inclusive, in the April, 1947, issue; 119-121, inclusive, in the July, 1947, issue; 122-124, inclusive, in the October, 1947, issue.

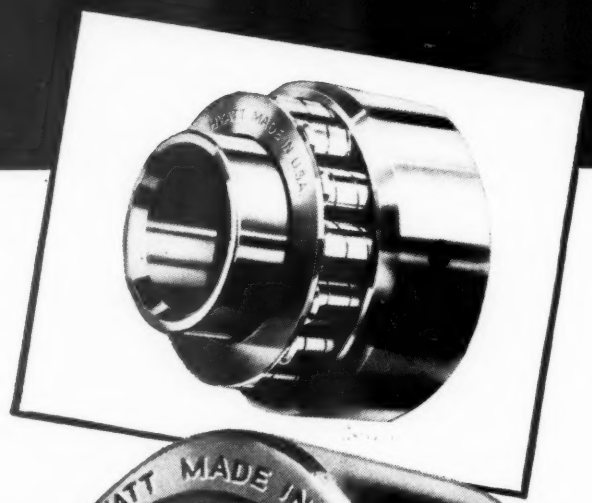
INDEX TO TABLES

		Index No.	Page	Issue
Methods of evaluating and operating gas-condensate reservoirs	(sheet 1)	P 502.7	223	Nov.
Methods of evaluating and operating gas-condensate reservoirs	(sheet 2)	P 502.7	225	Nov.
Methods of evaluating and operating gas-condensate reservoirs	(sheet 3)	P 502.7	203	Dec.
Methods of evaluating and operating gas-condensate reservoirs	(sheet 4)	P 502.7	205	Dec.
Methods of evaluating and operating gas-condensate reservoirs	(sheet 5)	P 502.7	209	Dec.
Methods of evaluating and operating gas-condensate resetvoirs	(sheet 6)	P 502.7	213	Dec.
Thermal method of locating tubing leaks in gas-lift wells		P 509.2	227	Nov.
Thermal method of locating casing leaks in producing wells		P 509.21	229	Nov.
Apparent viscosity of waxy crude oils at pipe line conditions	(sheet 3)	P 615.10	231	Nov.
Apparent viscosity of waxy crude oils at pipe line conditions	(sheet 4)	P 615.10	233	Nov.
Conversion chart for factors in the flow of liquids through pipes		P 731.101.	221	Nov.
Heat transfer coefficients of condensers, exchangers, and reboilers	(sheet 1)	P 734.2	201	Dec.
Heat transfer coefficients of condensers, exchangers, and reboilers	(sheet 2)	P 734.2	207	Dec.
Heat transfer coefficients of condensers, exchangers, and reboilers	(sheet 3)	P 734.2	211	Dec.

INDEX TO ADVERTISERS IN TABLES

		Page	Issue	Backing Table No.
Babcock & Wilcox Tube Co.	(sheet 1)	202	Dec.	P 734.2
Drilling Specialties Company	(sheet 6)	214	Dec.	P 502.7
Griscom-Russell Co.	(sheet 3)	212	Dec.	P 734.2
Reading-Pratt & Cady Division, American Chain & Cable Co.	(sheet 3)	204	Dec.	P 502.7
Toledo Pipe Threading Machine Co.	(sheet 2)	208	Dec.	P 734.2
Visco Products Co., Inc.	(sheet 4)	206	Dec.	P 502.7
Waldrip Engineering Company	(sheet 5)	210	Dec.	P 502.7

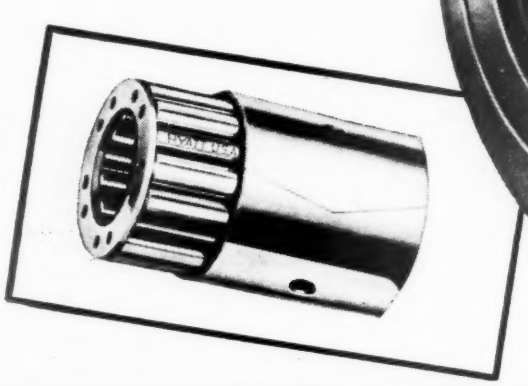
PRE-DETERMINED QUALITY That Pays Off



When it comes to roller bearings—most engineers and designers come to Hyatt for the right type and size—for an endless variety of applications.

These experts—for more than five decades—have designed in and specified Hyatt Roller Bearings for various sound and practical reasons. And over the years, Hyatts have given proof by performance that these men have chosen, and continue to choose, wisely.

Not only the correctness of design but the pre-determined quality of Hyatt Roller Bearings pays off to the manufacturer and the ultimate user of a Hyatt-equipped machine. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.



HYATT ROLLER BEARINGS

HEAT TRANSFER COEFFICIENTS OF CONDENSERS, EXCHANGERS, AND REBOILERS

● **Introduction.** The literature is replete with methods of calculating theoretical heat transfer coefficients for single films, but very little attention has been given to the most important problem of predicting commercial overall cofficients. It is generally true that inability to compute heat transfer rates with accuracy was not due so much to inadequacies in the transfer rate data, as to an inability to predict accurate fouling tendencies.

● **Commercial overall heat transfer coefficients.** Approximately 80 heat transfer coefficients were obtained on 24 commercial exchangers. The results of these tests are summarized in Tables 2-6.

The overall heat transfer coefficients were calculated from the equation

$$U = q/(A)(\Delta t) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where:

U = overall heat transfer coefficient, Btu/(hr) (sq ft) (°F),
q = heat transferred, Btu/hr,
A = area of the heating surface, sq ft,
Δt = temperature difference, ° F.

The heat transferred, q, was taken as the more reliable of either the heat input or out put (if they were of equal reliability, the average was taken). For water flows, the heat transferred was calculated from flow, obtained by an orifice type meter, and the temperature of the water entering and leaving (from calibrated thermometers or thermocouples). For refrigerant flows, the heat was obtained from the flow, metered as a liquid in an orifice-type flow meter and the enthalpy change from temperature and pressure conditions of the liquid entering and vapor leaving the exchanger. For steam, the heat was determined from the flow and the thermal conditions of the steam entering and the condensate leaving. The flow was determined by weighing the condensate in a tared drum with the proper correction being made for the portion flashed upon reduction to atmospheric pressure. Most of the process stream flows were determined from heat and material balances around the exchangers and consequently offer no check on the refrigerant or steam heat flows.

The temperature difference was in most cases the log mean temperature difference with the proper correction being made for non-true counter-current flow, McAdams[6]. In some cases, for example, boiling a pure liquid with steam, the use of the arithmetic mean temperature difference was satisfactory.

The actual heat transfer coefficients reported in Tables 2-6 are of value in themselves for they permit a quick estimation of coefficients for similar systems and have been of great value to the authors in preliminary process design work. Moreover, these coefficients were compared with theoretical overall coefficients to show the validity of the available theoretical methods.

● **Calculation of theoretical overall heat transfer coefficients.** Theoretical overall heat transfer coefficients may be calculated by the following *approximate* equation:

$$U = \frac{1}{\frac{1}{h_1} + \frac{1}{h_{f1}} + \frac{L}{k}\cdot\frac{D_1}{D_{av}} + \frac{D_1}{h_{f2}D_2} + \frac{D_1}{h_2 D_2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Where:

h_1 = heat transfer coefficient on tube side, Btu/(hr) (sq ft) (°F),
h_{f1} = heat transfer coefficient of the fouling material on the tube side,
L = thickness of tube, ft,
k = thermal conductivity of metal, Btu/(hr) (sq ft) (°F/ft),
h_{f2} = heat transfer coefficient of the fouling material on the shell side,
h_2 = heat transfer coefficient on the shell side,
D_1 = inside diameter of tube (ft),
D_2 = outside diameter of tube (ft),
D_{av} = average diameter of tube (ft).

Methods for evaluating the individual heat transfer coefficients available in the literature and applicable to this study are summarized below. For a more comprehensive review, the reader is referred to McAdams[6].

Fouling. Fouling in heat exchangers may be defined as the resistance to heat transfer resulting from the deposition of materials on the heat transfer surface. Fouling may result from the formation of a scale such as calcium carbonate, from carbon formation, from algae formation, or from foreign materials introduced with the stream being processed. Unfortunately, the determination of the extent of fouling to be expected is complicated because the fouling varies from day to day, plant to plant, system to system, and exchanger to exchanger. Values of fouling factors have been given by McAdams[6], Nelson[7], and the Tubular Manufacturers Association[9]. These were supplemented with fouling factors determined in the plant, and the values pertinent to the present study are given in Table 1. The fouling factor is related to the heat transfer coefficient by the relationship, $h_f = 10^3/$fouling factor.

TABLE 1. Fouling factors.

Service	Fouling factors*
Gases	
Steam	0
Hydrogen chloride	3
Low boiling hydrocarbons	1
Chlorinated hydrocarbons	1
Liquids†	
Water (either closed system or treated cooling tower water)	2-3
Low boiling hydrocarbons	1-2
Chlorinated hydrocarbons	1
Hydrochloric acid	0

*The fouling factor, f.f. $= 10^3/h_f$.
†These fouling factors do not hold for boiling liquids.

Heating and cooling fluids inside tubes. For the conditions found in this study, the Dittus and Boelter[4] equation, below, is considered best for heating or cooling ordinary fluids (liquids and gases) flowing in either vertical or horizontal tubes or pipes, provided that they have viscosities not more than twice that of water and values of DG/μ exceeding 2100.

$$h = 0.023\ k/D\ (DG/\mu)^{0.8}(c_p\mu/k)^{0.4} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where the terms are defined in the nomenclature.

Heating and cooling fluids outside tubes. BANKS OF TUBES. For heating or cooling (no change of state) liquids or gases flowing normal to banks of unbaffled tubes with values of D_oG_{max}/μ exceeding 2000, the equation of Colburn, given in McAdams[6], is recommended.

$$h = ak/D_o(c_p\mu/k)^{1/3}(D_oG_{max}/\mu)^{0.6} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where the constant, a, is equal to 0.33 for staggered and 0.26 for non-staggered tube banks; G_{max} is based on the minimum free area available for fluid flow. If baffles are used, the coefficient is taken as 0.6 times the value determined from the equation to allow for the leakage that normally occurs around the baffles.

FINNED SECTIONS AND ANNULAR SPACES. The use of the equivalent diameter, D_e, in the Dittus and Boelter[4] equation is recommended. The equivalent diameter may be determined for finned sections by the relationship:

$$D_e = 4S/b$$

where S = cross section open to flow and b = wetted perimeter. The equivalent diameter for annular spaces with the heat flowing through the inner pipe is determined by the following equation:

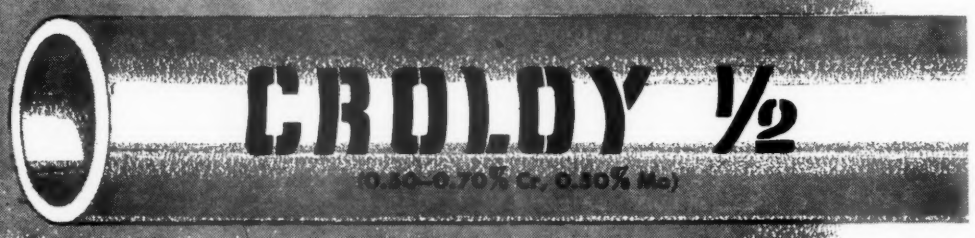
$$D_e = (D_2^2 - D_1^2)/D_1$$

Note: References are shown on the last sheet of this series of tables.

Taken from the article "Predicting Commercial Heat Transfer Coefficients," by E. P. Breidenbach and H. E. O'Connell, Ethyl Corporation, published in *AIChE Transactions*, vol. 42, Nos. 5-6, October-December, 1946, and in *The Petroleum Engineer*, Reference Annual, 1947, pages 191 to 198, inclusive.

new LOW-ALLOY steel

for HIGH TEMPERATURE STEAM LINES



BETTER carbide stability and greater creep strength qualify this new member of the B&W Croloy family as a superior seamless steel piping for carrying steam at temperatures as high as 1000F. Possibility of sudden pipe failure due to carbide instability is therefore offset where Croloy ½ is used. Weldability and workability — bending, flanging, etc. — of Croloy ½ pipe compares with that of carbon and straight carbon-molybdenum steels.

Croloy ½ pipe is available in sizes up to 8⅝ inches O.D. It conforms fully to ASTM Specification A-280-46T.

TENSILE PROPERTIES

Tensile Strength, min. psi
55,000

Yield point, min. psi
30,000

TA-1404S

B&W

BABCOCK & WILCOX SEAMLESS & WELDED TUBES

THE BABCOCK & WILCOX TUBE COMPANY
GENERAL OFFICES: BEAVER FALLS, PA.
PLANTS: BEAVER FALLS, PA. AND ALLIANCE, OHIO.

METHODS OF EVALUATING AND OPERATING GAS-CONDENSATE RESERVOIRS

The results of a number of such observations for a given gas condensate can be summarized as follows: At high temperatures, the mixture is entirely in the gaseous state or phase, and it remains gaseous at all pressures. This condition corresponds to the wet-type gas. At slightly lower temperatures, the mixture is in the gas phase at high pressures, but, when the pressure is reduced, a liquid phase condenses. This corresponds to the retrograde type gas. Therefore, it is seen that the particular type of classification into which a gas condensate falls depends not only on the amount of gas in the gas condensate as discussed hereinbefore, but also on the temperature and pressure of the reservoir. The same gas-condensate mixture can be classed as either of the two types, dependent on conditions.

Again, an explanation of the observation made in the field can be obtained in the laboratory. A bottom-hole sample from a La Blanca well[4] was placed in a bath at reservoir temperature as previously described. The material was found to be entirely in the gaseous state. However, when removal of gas from the reservoir was simulated by dropping the pressure in the sample container held at reservoir temperature, it was observed that a liquid was condensed within the container.

A logical explanation of what happens in the field is apparent. When the pressure is dropped, due to withdrawal of gas, a liquid condenses in the reservoir. This liquid, composed largely of condensate otherwise recoverable at the surface, "wets the sand" and, therefore, will not normally be produced by the wells.

This type of condensation, which is attributable to a drop in pressure while the temperature of the gas remains constant, is called "retrograde condensation." Similarly, the gas condensates, from which such condensation is observed at reservoir temperatures, are called herein "retrograde gases." Most of the gas-condensate reservoirs contain gases of this type.

It has been observed in laboratory tests that the amount of liquid which drops out by retrograde condensation is higher for rich gases, i.e., those from which large condensate yields are obtained. It has been estimated[5, 1] that approximately 50 per cent of the recoverable liquid content of some gas condensates would be lost by retrograde condensation in the formation if the reservoir were produced and the pressure allowed to decline. In the case of "lean" retrograde gases, the loss would be less. The laboratory evaluation of the amount of possible retrograde loss, using bottom-hole samples made by combining surface gas and liquid, has been described in the literature[1].

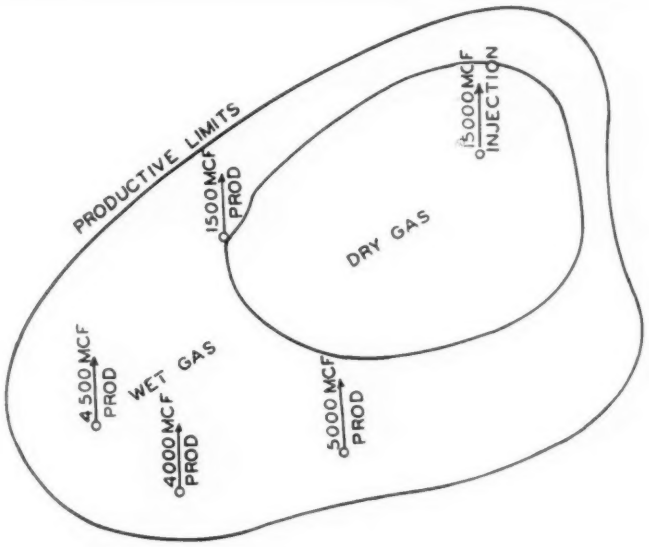


FIG. 3. Location of wells in typical cycling plan.

In order to reduce the loss due to retrograde condensation, the process called cycling (or recycling) has been developed. By this operation, gas condensate is produced from strategically located wells, the liquefiable hydrocarbons are removed, and the stripped gas, instead of being sold, is compressed and returned to the same reservoir from which it was produced through injection wells. These injection wells are also located strategically, and some distance from the producers. By injection of residue gas, pressure drop in the reservoir is prevented and, therefore, retrograde condensation is held to a minimum. Eventually, the injected "dry" gas displaces most of the "wet" gas between the injection and producing wells. These latter wells then begin to produce some of the dry gas, and the amount of wet gas produced begins to decrease. When the amount of dry gas becomes so large that the liquefiable hydrocarbons recovered from the small volume of wet gas will not pay operating expenses, the cycling process is abandoned. The gas in the field then can be sold, and reservoir pressure allowed to decline as in the case of the wet-gas type. It is estimated[6, 7] that between 60 and 80 per cent of the condensate in a reservoir can be obtained by cycling. If cycling is followed by gas sales, the recovery may, of course, be increased—possibly to 80 to 90 per cent.

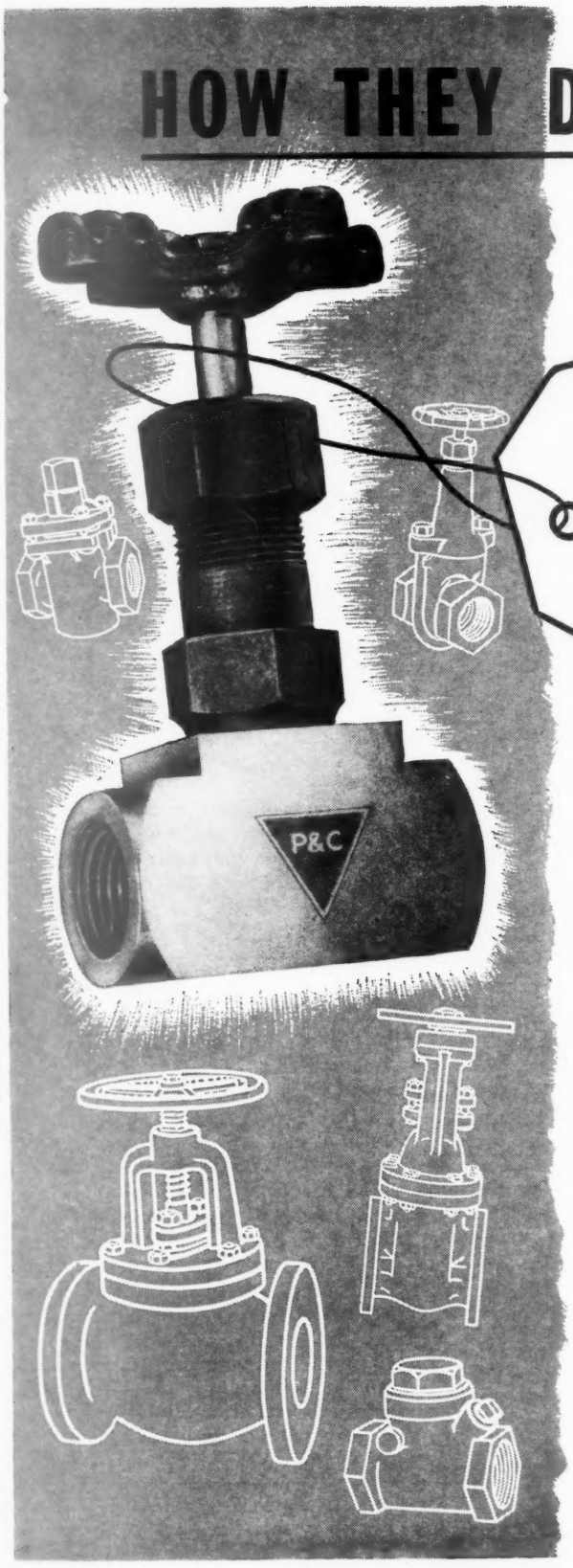
A map (Fig. 3) shows a typical arrangement of wells in a cycling project, with daily volumes produced and injected per well. Also the area occupied by dry gas at a particular time is designated to illustrate the mechanism of displacement of the gas.

The area shown in Fig. 3 as being occupied by dry gas was determined by what is called a "model study" of the reservoir[8]. It can be shown that the flow of gas in a reservoir follows the same pattern as the flow of electricity in a conductive "model" of the field. These models are built to scale, and current is put in at points corresponding to injection-well locations, and current is taken out at producing wells. The amount of current per well is made proportional to the volume of gas produced by, or injected into, the well. By actual experience, it has been found that the dry-gas patterns determined by model study agree reasonably well with those obtained by observing dry gas encroachment into producing wells. Of course, the dimensions of and conditions in the reservoir must be accurately known, so that the model is an accurate picture of actual subsurface conditions. The use of electric models as guides by operators of cycling projects now is widespread.

Note: References will be found on sheet 6 in this series of tables.

Taken from the article, "Gas-condensate reservoirs—a review," by O. F. Thornton, The Texas Company, published in *The Petroleum Engineer*, Reference Annual, 1947, pages 124 to 138, inclusive. This paper was presented before the annual meeting of the American Petroleum Institute, Chicago, Illinois, November 12, 1946.

HOW THEY DO GET AROUND!



Reading-Pratt & Cady
BAR STOCK VALVES

They were first introduced by R-P & C as close control valves. But these tough little globe and angle valves have such a wide pressure and temperature range — give satisfactory service in so many kinds of applications — that many users think of them as general purpose valves.

Reading-Pratt & Cady Bar Stock Valves are precision-machined from highest quality bar stock—bronze, carbon steel or alloy steel. Working pressures range from 4000 pounds at 150°F. to 475 pounds at 1000°F.

DESCRIPTIVE CATALOG. Send for our new catalog which describes the advantages and limitations of R-P & C Bar Stock Valves. Just write for DH-766.

ACCO

Reading, Pa. • Atlanta • Baltimore • Boston • Chicago • Denver • Detroit • Houston • Los Angeles • New York • Philadelphia • Pittsburgh • Portland, Ore. • San Francisco • Bridgeport, Conn.

TRADE MARK

READING-PRATT & CADY DIVISION
AMERICAN CHAIN & CABLE

METHODS OF EVALUATING AND OPERATING GAS-CONDENSATE RESERVOIRS

● **Relation of types.** In discussing each of the gas condensates, viz., the wet gas and retrograde gas types, it was desirable to describe the properties of the gas condensate in the laboratory under reservoir conditions of temperature and pressure. In order to point out the similarity between the types, once again laboratory tests will be resorted to.

Assume that another bottom-hole sample of gas condensate is obtained. In the laboratory, it is observed to be entirely in a gaseous state at reservoir temperature and pressure. Now, instead of reducing pressure in the container by bleeding off gas, let the pressure drop be accompanied by expanding the size of the container. This may be done by a movable piston in one end of the container. Further, inasmuch as conditions can be varied at will in the laboratory, observations can be made at any desired temperature in addition to that of the reservoir. Therefore, the characteristics of the gas condensate can be observed at a great many combinations of pressure and temperature.

Fig. 4 is a picture of the previously given word summary, called a "phase diagram." There are three regions on this diagram: in one, the pressure and temperature are such that only a gas phase is present; at slightly lower temperatures and at intermediate pressures, both gas and liquid phases are present, i.e., a two-phase region; at lower temperatures and high pressures, only a liquid phase is present.

Assume that reservoir conditions of temperature and pressure correspond to the point P_1 in the diagram. The mixture is entirely in the gas phase. If, at the constant reservoir temperature, the pressure were dropped (as by production of gas from the reservoir), the cirresponding path on the phase diagram would be a vertical line from P_1. It will be noted that such a line does not enter the two-phase region; the mixture remains entirely a gas, or behaves as a wet gas.

If pressure-temperature conditions of the reservoir were equivalent to those designated by P_2, the mixture would be in a gaseous state. If, at the constant reservoir temperature, the pressure were dropped (as in the La Blanca field), a liquid would condense. This is shown in the phase diagram by the vertical line crossing into the two-phase region. Consequently, the mixture would be classed as a retrograde gas. The pressures at which the liquid first began to condense is called the "retrograde dew point." If the pressure were dropped to a very low value (an extension of the vertical line from P_2), the region wherein a gas phase only is present again would be entered. This means that the liquid that condensed as described would revaporize if the pressure were reduced to a very low value.

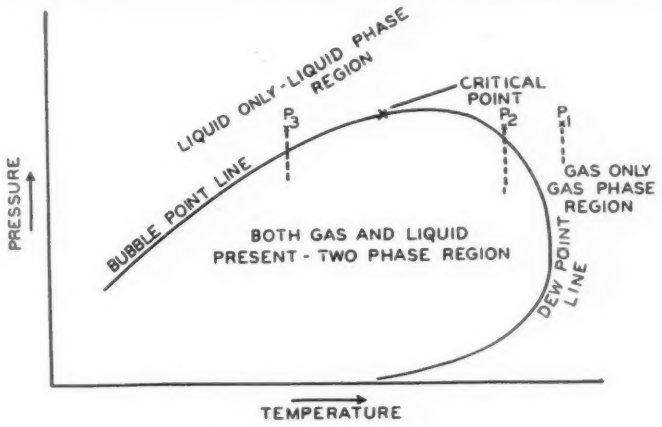


FIG. 4. A phase diagram.

In a similar manner, it will be noted that if the reservoir fluid is at a reservoir temperature and pressure corresponding to P_3, it is entirely in a liquid phase. A drop in pressure causes a gas to be liberated (two-phase region). The pressure at which a gas first forms is called the "bubble point."

It was stated previously herein that at certain conditions the reservoir fluid was entirely in a gas phase, whereas at others it was wholly a liquid. The question may be asked: "How is it determined that the mixture is a gas and not a liquid?"

At extremely high pressure of the reservoir, many familiar concepts of "liquids" and gases" no longer apply. For instance, at 6000 psi gases are compressed to about one-four hundredth of their volume at atmospheric pressure. A cubic foot of gas is reduced in volume to less than a 2-in. cube. At these high pressures, therefore, gases begin to react much like liquids. Conversely, when as much as 2000 to 5000 cu ft of gas is mixed with a barrel of liquid (about 5 cu ft), the mixture begins to react much like a gas at high pressure.

As a matter of fact, there is one condition of temperature and pressure for each gas condensate, called the "critical point" (Fig. 4), where it is impossible to distinguish whether the gas condensate is a liquid or a gas. As this point is approached, the gas and liquid phases become identical in all characteristics.[7-9]

● **Critical type.** Some gas-condensate reservoirs have been discovered in which conditions are very close to the critical. As a rule, the gas to liquid ratio in such cases is below 10,000 cu ft per bbl.

Laboratory evaluation of this "critical" type of gas-condensate is difficult, and often it is impossible by direct observation to distinguish whether the gas-condensate is a gas or a liquid at reservoir conditions.

Where it can be established that the mixture is a liquid at reservoir conditions, it may be argued that such a material is truly a crude oil and that operation of the reservoir should be the same as for a conventional oil reservoir. However, the losses that could result from such practices should be pointed out.

The liquid produced from these reservoirs is similar to that described for typical gas-condensate reservoirs. It is light straw in color and has a high API gravity. It contains a large amount of light hydrocarbons. If more gas is mixed with the liquid than was produced with it—say on the order of 10,000 cu ft per bbl—it can be observed in the laboratory that the mixture is entirely in a gaseous state at reservoir conditions of temperature and pressure. The liquid therefore has all the attributes of typical condensate; however, the amount of gas present with it is insufficient to "dissolve" it at reservoir conditions.

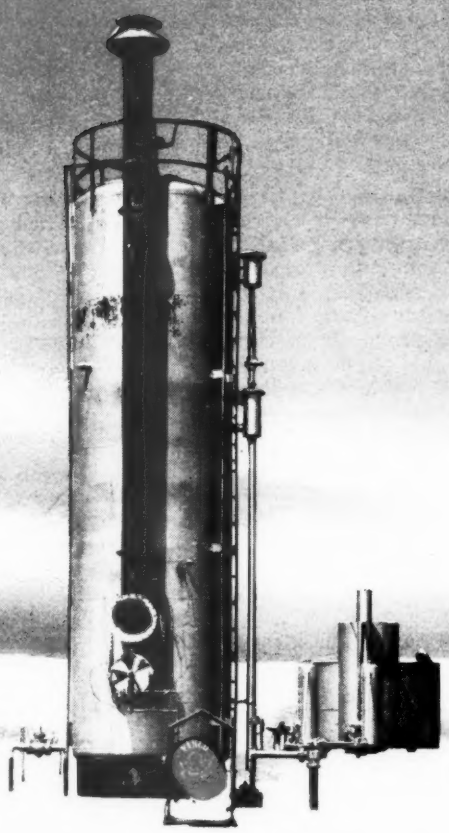
The losses by the conventional crude oil operating practices applied to this type of reservoir will be great. First, the loss of butanes, pentanes and other light hydrocarbons due to conventional separator operation amounts to 10 to 25 per cent or more of the liquid recoverable by plant processing. Second, the recovery by any operation whereby the reservoir pressure is not maintained will be very low—from 10 to 25 per cent of the amount originally in the reservoir. If pressure is maintained by gas injection, by water injection, or by restricting production to take advantage of a natural water drive, the recovery can be increased to 40 to 70 per cent or higher.

Note: References will be found on sheet 6 in this series of tables.

Taken from the article, "Gas-condensate reservoirs—a review," by O. F. Thornton, The Texas Company, published in *The Petroleum Engineer*, Reference Annual, 1947, pages 124 to 138, inclusive. This paper was presented before the annual meeting of the American Petroleum Institute, Chicago, Illinois, November 12, 1946.

A Merry Christmas

from
VISCO
the modern
FAST, EFFICIENT
ECONOMICAL
EMULSION
BREAKER



VISCO

DEHYDRATING
•
DESALTING

VISCO PRODUCTS COMPANY, INC., Houston, Texas

NOTICE: Visco Products Company is authorized to manufacture and sell Visco Oil Treating compounds for use in the breaking and resolving of oil emulsions, and to grant licenses for such use, under the following United States patents: 1,860,562; 1,860,563; 1,912,330; 1,937,259; 2,050,639; 2,050,640; 2,206,589; 2,214,783; 2,214,784; 2,225,189; 2,303,414; 2,307,813; 2,318,034; 2,318,035; 2,321,056; 2,335,554. Re. 20,717 and patents pending. Any purchaser of Visco oil treating compounds is authorized to use the same in the treating, breaking and resolving of oil emulsions in accordance with the above patents. The royalty for such use is included in the purchase price. Visco Products Company is authorized to and is willing to grant licenses on a royalty basis, to all companies, and to others desiring to practice the patented subject matter, under any and all of the above patents, permitting the user to purchase the oil treating compounds at will from any vendor, and to prepare the compounds for use under the above patent or patents, at a royalty charge of 20 cents per gallon. Application for license should be made to **Visco Products Company**, Houston, Texas.

HEAT TRANSFER COEFFICIENTS OF CONDENSERS, EXCHANGERS, AND REBOILERS

Condensing vapor films. The coefficient for film-type condensation of vapors outside banks of tubes (or single finned tubes) may be approximated from the Colburn[3] equation:

$$h = jc_pG_c(c_p\mu/k)^{-2/3} \quad . \quad . \quad . \quad . \quad (5)$$

where j is defined as the heat transfer factor, values of which may be taken from Fig. 1 (for finned sections, use the lower curve), and G_c is the mass velocity of the condensate film, which, according to Atkins[1], may be expressed by the following equation:

$$G_c = 36{,}000 + EG_v(\rho_l/\rho_v)^{1/2} \quad . \quad (6)$$

where 36,000 is the component attributable to gravity and E is a constant to correct for the incomplete interaction between the condensate and vapor films, being 0.3 for a horizontal travel of condensate of more than 200 in., 0.4 for travel of from 50 to 200 in., and 0.5 when the bundle is vertical and for finned sections. This equation may be used for both pure vapors and mixtures of condensable and non-condensable vapors. In the case of total condensation, the vapor film resistance is zero, but the effect of vapor drag, G_v, must be taken into account for determining G_c. For this case, use G_v equal to one-half the total condensate (average of 100 and 0 per cent vapor).

Vapor film in the presence of condensing vapor films. The resistance of the vapor film in contact with a condensing vapor film may be determined by the equation of Atkins[1], which was derived from the Colburn[3] equation (5 above).

$$1/h = \frac{(S)\,(T.R.)}{(q)\,(j)}(c_p\mu/k)^{2/3} \quad . \quad (7)$$

where S is the cross-section open to flow, sq ft; T.R. is the temperature range, ° F, between inlet and outlet; q is the heat transferred; and j is the heat transfer factor, values of which may be taken from Fig. 1.

Boiling liquids. No correlations are available for the prediction of heat transfer to boiling liquids because all the variables which affect the rate of boiling are not known *(see* Drew and Mueller[5]). It is practically impossible therefore to predict the coefficients for reboilers unless experience is had with the system in question. In condensers, however, where a boiling refrigerant is used as a cooling medium, the resistance to heat transfer caused by the boiling film is generally so small in comparison with the condensing film that it contributes but little reduction in the over-all coefficient.

Taken from the article "Predicting Commercial Heat Transfer Coefficients," by E. P. Breidenbach and H. E. O'Connell, Ethyl Corporation, published in *AIChE Transactions*, vol. 42, Nos. 5-6, October-December, 1946, and in *The Petroleum Engineer*, Reference Annual, 1947, pages 191 to 198, inclusive.

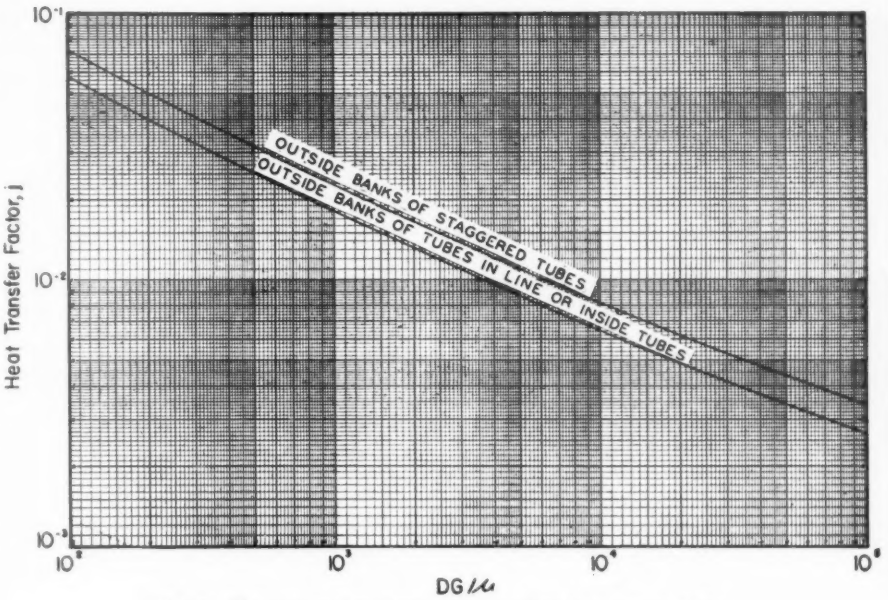


FIG. 1. Heat transfer factor for condensing vapor films.

TABLE 2. Comparisons of actual and calculated heat transfer coefficients for partial condensers.

Test No.	Type	Surface area, sq ft	Fluid flowing in: Tube side	Fluid flowing in: Shell side	Heat load, M Btu/hr	Δt °F	Heat flux density Btu/(hr) (sq ft)	Coefficient, Btu/(hr) (sq ft) (°F): Actual	Coefficient, Btu/(hr) (sq ft) (°F): Calc.	Per cent Deviation*
1	Shell and tube	312	Condensing mixture of chlorinated hydrocarbon and hydrocarbons.	Water	235	30.5	753	24.7	15.5	+ 37.3
2					152	31.4	487	15.5	20.2	− 30.3
3					116.6	27.7	374	13.5	12.6	+ 6.7
4	Shell and tube	59	Condensing mixture of ethanol, hydrogen chloride and water.	Water	526	120.7	8,925	73.8	.....	.....
5	Shell and tube	100	Condensing mixture of chlorinated hydrocarbon and hydrocarbons.	Boiling propane	92.5	40.2	925	23.0	24.4	− 6.1
6					267	84.7	2,670	31.5	36.8	− 16.8
7					284	87.0	2,840	32.6	37.3	− 14.4
8	Shell and tube	1500	Condensing mixture of chlorinated hydrocarbon and hydrocarbons.	Boiling propane	2,460	21.6	1,640	76.0	67.8	+ 10.8
9					2,900	27.3	1,934	70.8	69.8	+ 1.4
10					3,275	33.8	2,180	64.5	66.0	− 2.3
11					2,780	27.1	1,852	68.4	68.5	− 0.2
12					2,910	27.3	1,940	71.0	70.8	+ 0.3
13					3,100	33.9	2,065	61.0	68.8	− 12.8
14					3,320	29.3	2,210	75.5	71.0	+ 6.0
15	Shell and tube	682	Condensing mixture of low boiling hydrocarbons.	Boiling propane	282.9	7.62	415	54.5	43.9	+ 19.5
16	Shell and tube	2000	Condensing mixture of chlorinated hydrocarbon and hydrocarbons.	Boiling ethylene	682	10.2	341	33.4	74.8	−124.0
17					563	6.8	281	41.2	32.4	+ 21.4
18					354	12.9	177	13.7	19.2	− 40.1

*$\frac{\text{actual-calculated}}{\text{actual}}$

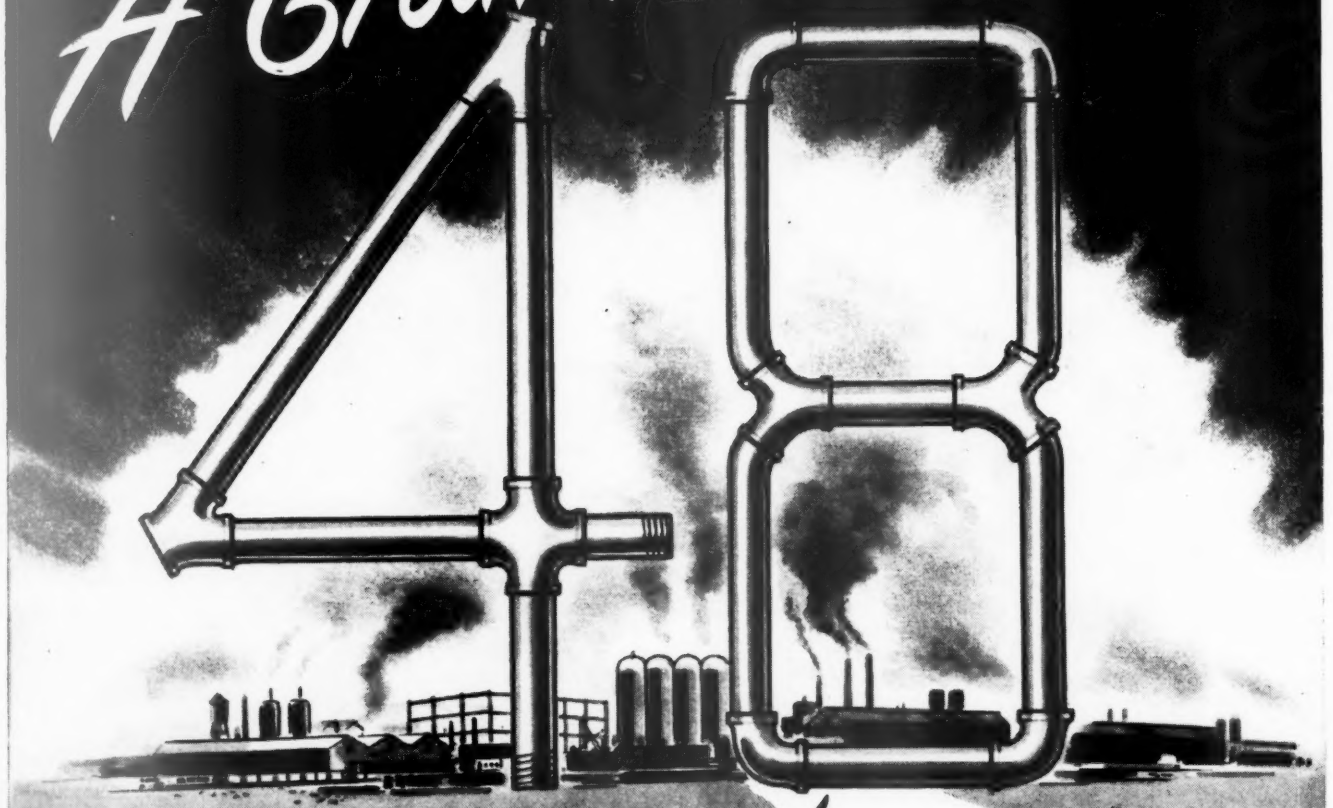
TABLE 3. Comparisons of actual and calculated heat transfer coefficients for total condensers.

Test No.	Type	Surface area, sq ft	Fluid flowing in: Tube side	Fluid flowing in: Shell side	Heat load, M Btu/hr	Δt °F	Heat flux density Btu/(hr) (sq ft)	Coefficient, Btu/(hr) (sq ft) (°F): Actual	Coefficient, Btu/(hr) (sq ft) (°F): Calc.	Per cent Deviation*
19	Shell and tube	2400	Water	Condensing chlorinated hydrocarbons.	2,660	14.8	1,109	75.0	54.7	+ 27.1
20					2,135	15.3	890	58.0	53.5	+ 7.8
21					2,560	17.8	1,068	60.1	56.5	+ 6.0
22					3,280	32.5	1,375	42.0	40.3	+ 4.0
23					2,565	37.1	1,070	28.8	39.8	− 38.2
24					2,770	24.8	1,154	46.5	46.0	+ 1.1
25					3,345	28.6	1,395	48.8	.....	.....
26					2,340	17.4	975	56.0	50.6	+ 9.6
27	Shell and tube	354	Water	Condensing chlorinated hydrocarbons.	950	44.7	2,680	60	62.2	− 3.7
28					890	39.9	2,510	63	63.2	− 0.3
29					1,096	44.0	3,095	70.3	68.2	+ 3.0
30	Shell and tube	900	Water	Condensing chlorinated hydrocarbons.	675.0	25.0	750	30.0	60.5	−101.5
31	G-fin	79.8	Water	Condensing chlorinated hydrocarbons.	1,017	93.3	12,760	136.4	120.1	+ 11.9
32					914	84.8	11,460	135.0	113.4	+ 16.0
33	G-fin	212	Water	Condensing chlorinated hydrocarbons.	592.9	40.7	2,800	68.6	93.3	− 36.0
34					844.1	47.2	3,980	84.5	103.0	− 21.9
35					829.3	35.0	3,905	111.7	103.4	+ 7.4

Note: References are shown on the last sheet of this series of tables.

*$\frac{\text{actual-calculated}}{\text{actual}}$

A Great Year Ahead



...IF WE BUILD IT *Right*

Heartiest Good Wishes to our many friends in industry, engineering and the building fields!

In the year ahead — *pipe* will continue to "carry the load" for progress in America! And the men who work with pipe will continue to be "key men in production" in all branches of building and industry.

Be sure these men have the *right* tools. For all pipe fitting requirements—they'll do *better work, faster,* and *cut costs*... with Toledo Pipe Tools! The man on the job will do his best work with the tools he likes best. Thousands prefer TOLEDO — the choice of better mechanics for nearly half a century. The Toledo Pipe Threading Machine Company, Toledo, Ohio. New York Office, No. 2 Rector Street Building.

TOLEDO No. 999 POWER PIPE MACHINE. Small, compact, portable for cutting, threading and reaming pipe up to and including 2" and bolts from ⅜" to 1½". A high production machine for shop, job use or industrial plants.

RELY ON THE LEADER

TOLEDO

FOR PRECISION PIPE TOOLS

METHODS OF EVALUATING AND OPERATING GAS-CONDENSATE RESERVOIRS

Table 3 gives data for several gas-condensates and crude oils to illustrate the types previously discussed herein.

TABLE 3. Comparison of gas condensates with crude-oil-gas mixtures.

	API gravity of liquid, deg	Gas-liquid ratio, cu ft per bbl	Reservoir conditions		Retrograde dew point, psi	Bubble point, psi
			Temperature, °F	Pressure, psi		
Gas condensate:						
Wet gas	65	67,000	160	1,700	..	..
Retrograde gas	55	18,500	203	4,810	4,470	..
Reservoir liquid	58	2,700	203	4,700	..	3,855
Crude-oil-gas mixture:						
Mid Continent	38	540	98	1,760	..	1,700
Gulf Coast	38	900	211	4,750	..	4,600

TABLE 4. Comparison of extraction methods.

	Conventional separation	Multi-stage separation	Plant Extraction
1. Barrels of liquid per million cubic feet of retrograde gas	52	58	70
2. API gravity of recovered liquid, deg	54.7	58.4	64.4

● **Occurrence with oil reservoirs.** Wet and retrograde gases often occur as gas caps to crude oil reservoirs. The amount of oil present in such reservoirs has been found to vary considerably. It may be present only as a thin rim of liquid around the flanks of the structure, and may have no commercial significance—or oil may occupy in excess of 90 per cent of the pore space in the reservoir. The relative amounts of oil and gas condensate in such reservoirs have an important bearing upon the operating methods used, and upon the timing of recovery of the two reservoir fluids. In general, the practice has been to give primary consideration to recovery of oil, and recovery from the gas-condensate zone has often been deferred until exploitation of the oil zone was completed. If ownerships of the oil and gas condensate are diversified, some inequity of income at times may result in such cases.

More often than not several gas-condensate reservoirs are found in the same field. The integration of the simultaneous operation of two or more such reservoirs calls for ingenuity in well-completion practices and timing of recovery.

The basic principles governing best operating methods for gas-condensate reservoirs are not unique and, according to modern thought, are the same as for most oil reservoirs.[6] However, physical waste due to improper operation is both more serious and more easily discernible in the gas-condensate reservoirs and, therefore, the application of these basic principles has been more the rule than the exception. These principles are: (1) Selection of operating methods based upon the character of the reservoir fluids; (2) maintenance of pressure in those reservoirs where a decrease would result in loss of recovery underground; (3) efficient handling of produced fluids at the surface to obtain maximum liquid extraction; (4) optimum spacing of wells to obtain highest recovery; and (5) unitization of interests to assure equity to all parties having ownership in the common reservoir, and to enable application of principles (1), (2), (3), and (4).

Gas-condensate operations may be divided into two classes: (1) Those concerned with efficient recovery of gas condensate from the reservoir through the wells, and, (2) those pertaining to extraction of the liquefiable hydrocarbons from the well production. These two classes of operations are in many cases of equal importance. Inefficient extraction can result in losses as great as those due to retrograde condensation, or inefficient recovery.

The "cycling" operation previously described is now widely utilized for recovering retrograde gases. It is not necessary to cycle wet-type gases to prevent loss of condensate underground. Often, however, no market for gas exists, and by the cycling process the condensate can be recovered without awaiting the development of an adequate gas outlet. If the gas is the gas cap of an oil reservoir, cycling may enable the recovery of the condensate simultaneously with the oil.

Gas injection to maintain pressure and and prevent retrograde condensation is not necessary if water encroaches into the reservoir as a retrograde gas is produced. In the case of wet gas reservoirs, obviously the pressure need not be maintained, because no condensation takes place in the reservoir as pressure declines. In such cases, when there is a market for gas or when it may be utilized legally for some other purpose, gas-condensate reservoirs may not be cycled.

In the case of critical type reservoirs, maintenance of reservoir pressure is indicated. Injection of gas, injection of water, and restriction of producing rate to take full advantage of natural water drive are commonly applied for "pressure maintenance."

Methods of extracting condensate or other liquefiable hydrocarbons from the well production may be classed as: (1) Separation of gas and condensate in a conventional oil separator operating at approximately atmospheric temperature and a pressure ranging from 100 psi to 500 psi or more; (2) multi-stage separation as described hereinafter, and (3) extraction in a processing plant. These methods are in order of increasing efficiency.

In Table 4 are given the barrels of liquid recoverable by each of the foregoing methods from one million cubic feet of a typical retrograde gas.

Summarizing the foregoing, present operating methods or those utilized in the past for gas-condensate reservoirs are combinations of: (1) cycling; (2) gas sales or storage; or (3) pressure maintenance—with one of the three extraction methods, as indicated in Table 5.

TABLE 5. Operating methods—summary.

Recovery methods	Extraction methods
1. Cycling	a. Separator—conventional
2. Gas sales or storage	b. Separator—multi-stage
3. Pressure maintenance	c. Plant

The operating method used in a particular case depends upon the evaluation of a number of factors.[10] Obviously, the amount of recoverable liquid in the gas is very important. The cycling and plant processing of gas condensates containing less than 20 bbl to 25 bbl of liquid per million cubic feet usually is not financially attractive, unless there is a market for some of the residue gas from the plant. Also, the size of the reserve must be sufficient to pay out plant and well investments and to yield a reasonable return. Many small reservoirs, containing comparatively rich gas condensates, will not support a processing plant and pay out the cost of installing a compressor plant for cycling without some sale of gas concurrent with cycling.

The capacities of wells are an important factor. Low capacity means a large number of both producing and injection wells must be drilled, resulting in high investment and operating costs.

Note: References will be found on sheet 6 in this series of tables.

Taken from the article, "Gas-condensate reservoirs—a review," by O. F. Thornton, The Texas Company, published in *The Petroleum Engineer*, Reference Annual, 1947, pages 124 to 138, inclusive. This paper was presented before the annual meeting of the American Petroleum Institute, Chicago, Illinois, November 12, 1946.

slanted toward safety

safety feature

Safety, combined with dependability and economy of operation were outstanding considerations in the design of WALDRIP AIR-BALANCE PUMPERS.

One of the most important Safety Features is that one man, while standing on the derrick floor, can set the horsehead back for well clearance by an easily actuated worm and wheel mechanism. It is not necessary to remove the horsehead from the walking beam, thus saving considerable time.

The Safety Features of Waldrip Air-Balance Unit Pumpers provide extra safety for all parts of the pumping equipment as well as for the production crew—write for complete details.

CHECK THESE OUTSTANDING FEATURES

- **Longer sucker rod life**
- **Less shutdown time**
- **Better prime mover performace**
- **Increased V-belt life**
- **More compact, economical and easier to install**
- **Simple and precise adjustment of counterbalance effect**
- **Ease and safety of operation**

WALDRIP ENGINEERING, HOLLYDALE, CALIF.

HEAT TRANSFER COEFFICIENTS OF CONDENSERS, EXCHANGERS, AND REBOILERS

Cross-section open to flow. The cross-section open to flow in the shell side of shell and tube exchangers may be calculated by the following method given by Atkins[1].

1. Determine the net cross-section open to flow by subtracting the area occupied by the tubes from the cross-sectional area of the shell or of the bundle if deflector plates are used.

2. Determine the cut-out segment of the baffle and subtract the area of the tubes passing through it. Call this the free cross-section.

3. Determine the linear dimension of the baffle, W, by the equation [W = inside diameter of shell X (1 — F.C.S./N.C.S.)].

4. Increase the linear dimension by a factor depending on tube layout:

1.5 for ¾-in. OD tubes on 1-in. square pattern.

2.0 for ¾-in. OD tubes on 1-in. triangular pattern.

This gives the lateral dimension, x.

5. Determine the distance between the baffles, y, and calculate the diagonal dimension, z, between the inlet and outlet.

$$z = (x^2 + y^2)^{1/2}$$

6. The cross-section open to flow, S, is determined from the equation

$$S = (N.C.S.)\,(y/z) \quad . \quad . \quad . \quad . \quad (8)$$

● ***Comparison of calculated with actual coefficients.*** The coefficients obtained from tests on commercial apparatus and those calculated by the methods described in the previous section are compared and discussed below. The comparisons are given by exchanger types.

Partial condensers. In a partial condenser, the vapor is cooled with either water or refrigerant, to such an extent that only part of the vapor is condensed. Thus, on the condensing side, there is a vapor film in contact with a condensing film. The overall coefficients for water-cooled condensers were calculated in the following manner.

1. The condensing film was calculated by equation (5) as shown above in *Condensing vapor films.*

2. The vapor film was calculated by equation (7) in *Vapor film in the presence of condensing vapor films.*

3. The water film was calculated by equation (3), the conditions of the test fulfilling the requirements of the equation.

4. The fouling factors were obtained from Table 1 and were two for the water side and one for the condensing chlorinated hydrocarbon side.

5. The above coefficients along with the metal coefficient were substituted into equation (2) to give the theoretical overall coefficient.

TABLE 4. Comparisons of actual and calculated heat transfer coefficients for liquid-liquid exchangers.

Test No.	Type	Surface area, sq ft	Fluid flowing in: Tube side	Fluid flowing in: Shell side	Heat load, M Btu/hr	Δt °F	Heat flux density Btu/(hr) (sq ft)	Coefficient, Btu/(hr) (sq ft) (°F): Actual	Coefficient, Btu/(hr) (sq ft) (°F): Calc.	Per cent Deviation*
36	Shell and tube	2465	Impure chlorinated hydrocarbons.	Water	785	2.83	318	112	107.6	+ 4.0
37					490	1.48	199	134	112.6	+ 15.9
38					2,330	11.15	945	84.7	83.9	+ 0.9
39					1,280	6.46	520	80.1	80.4	— 0.4
40	Shell and tube	980	Water	Water	6,820	51.1	6,960	136.1	133.6	+ 1.8
41	G-fin	212	Water	Chlorinated hydrocarbon.	182	23.8	858	36.0	36.1	— 0.3
42					155	18.9	730	38.6	32.6	+ 15.6
43	Vertical	1575	Impure chlorinated hydrocarbon.	Water	649	35.0	411	11.8	.....	.....
44	Shell and tube				955	41.0	606	14.8	.....	.....
45					1,150	27.4	730	26.7	.....	.....

*$\frac{\text{actual-calculated}}{\text{actual}}$

TABLE 5. Comparison of actual and calculated heat transfer coefficients for gas exchangers.

Test No.	Type	Surface area, sq ft	Fluid flowing in: Tube side	Fluid flowing in: Shell side	Heat load, M Btu/hr	Δt °F	Heat flux density Btu/(hr) (sq ft)	Coefficient, Btu/(hr) (sq ft) (°F): Actual	Coefficient, Btu/(hr) (sq ft) (°F): Calc.	Per cent Deviation*
46	Horizontal	635	Chlorinated hydrocarbon vapors with small degree of condensation.	Hydrocarbon gases	384	45.6	604	13.3	15.4	— 15.8
47	Shell and tube				364	52.4	573	10.9	12.6	— 15.6
48					382	49.2	601	12.2	12.9	— 5.7
49					439	50.6	690	13.6	14.5	— 6.6
50					542	49.8	855	17.1	15.4	+ 10.0
51					532	49.0	839	17.1	15.8	+ 7.6
52					429	47.8	675	14.1	13.9	+ 1 4
53	G-fin	205	Water	Hydrocarbon gas	80	27.4	390	14.2	22.0	— 55 0

*$\frac{\text{actual-calculated}}{\text{actual}}$

For the propane-cooled condensers, the boiling propane film coefficient could not be calculated but was estimated as 500 Btu/(hr) (sq ft) (° F). This estimate was in order inasmuch as the boiling film resistance was negligible in comparison with the controlling vapor film resistance. Care should be used in making such assumptions when the over-all coefficient is more than seventy-five.

Comparisons of calculated and actual over-all heat transfer coefficients tor partial condensers are given in Table 2.

Total condensers. In the condensers studied, the vapor was condensed on the shell side with the water coolant flowing through the tubes. The theoretical coefficients were calculated in the same manner as the partial condenser expect that there was no vapor film and consequently no vapor-film resistance. Comparisons of calculated and actual coefficients are given in Table 3.

Liquid to liquid exchangers. The liquid exchangers of the shell and tube type were calculated as follows:

1. The tube side coefficient was calculated by equation (3).

2. The shell side coefficient was calculated by equation (4). The mass velocity was based on the minimum cross section as calculated in *Cross-section open to flow.*

3. The fouling factors were selected from Table 1, and were two for the water side and one for the chlorinated hydrocarbon side.

For the G-Fin exchanger, the shell or fin side coefficient was calculated by equation (3), with the equivalent diameter, D_e, substituted for the internal pipe diameter.

Comparisons of the calculated and actual coefficients for the liquid-liquid exchangers are given in Table 4. Theoretical coefficients for tests 43-45 on a vertical shell and tube exchanger could not be calculated because the physical properties of the material flowing on the tube side were unknown.

Gas exchangers. There were only a few examples of gas exchangers in the plant. These included:

1. A shell and tube heat exchanger where heat was recovered from a gas by interchange with a partially condensing vapor. For this case, the gas film was calculated from equation (3) and the condensing vapor and vapor films were calculated as shown under *Partial Condensers.*

2. A G-Fin exchanger where a low boiling hydrocarbon vapor on the fin side was cooled with water. The vapor film was calculated by equation (3) with appropriate correction being made for the extended fin surfaces. The water film was calculated by equation (3).

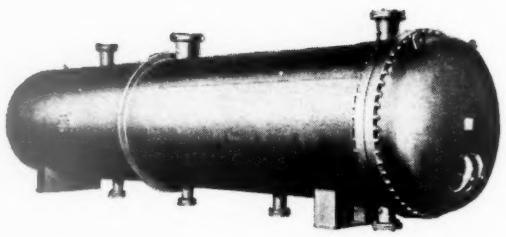
Comparisons of the calculated and actual coefficients for these cases are given in Table 5.

Note: References are shown on the last sheet of this series of tables.

HOW G-R has led in EVAPORATOR DESIGN and APPLICATION

1st. .... G-R DEVELOPED

- THE FIRST *marine evaporator*
- THE FIRST *stationary evaporator*
- THE FIRST *"multiple-effect" system*
- THE FIRST *"associated" system*
- THE FIRST *"scale-shedding" elements*
- THE FIRST *"reducing valve" system*
- THE FIRST *"waste heat" evaporator*

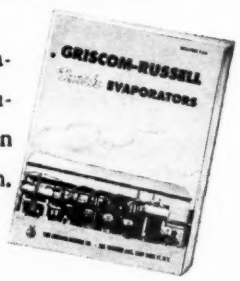


The many G-R "firsts" in the development of evaporators for producing pure boiler feed make-up indicate the leadership which has resulted in installations serving a total of more than 40,000,000 boiler horsepower.

The different types of evaporator systems which have been originated by G-R provide an efficient arrangement for a wide variety of requirements . . . for example; "associated" systems for maximum heat economy in high-duty plants, "reducing-valve" systems for economical generation of process steam in industrial plants, "waste heat" evaporators for recovering the heat from hot process fluids in petroleum refineries and chemical plants.

In addition, the many distinctive features of G-R Bentube Evaporators . . . their scale-shedding elements, provisions for pure dry vapor, dependable operation, and convenience of access to all parts . . . assure economy of attendance and maintenance as well as thorough elimination of all raw-water impurities.

Investigate G-R Bentube Evaporators . . . write for Bulletin 364 and authoritative advice, without obligation, on your boiler feed purification problem.



THE GRISCOM-RUSSELL CO.

285 Madison Avenue • New York 17, N. Y.

GR-185

GRISCOM-RUSSELL

Pioneers in Heat Transfer Apparatus

METHODS OF EVALUATING AND OPERATING GAS-CONDENSATE RESERVOIRS

Recovery by a conventional separator is relatively low, ranging from 40 per cent or less to 85 per cent of that obtainable in a plant, depending upon the composition of the gas condensate. By multi-stage separation, recovery efficiency may be increased over that obtainable by use of one separator. Multi-stage separation (or simply stage separation) is illustrated diagrammatically in Fig. 5. Well production enters a separator operating at high pressure, on the order of 1000 psi. The pressure selected usually is the one at which the separator gas retains the least amount of liquefiable hydrocarbons, or the "optimum separator pressure." Liquid from the first separator goes to a second separator at a lower pressure where additional gas is liberated, and so on through additional separators until atmospheric pressure is reached. The temperatures in each of the separators also may be controlled.

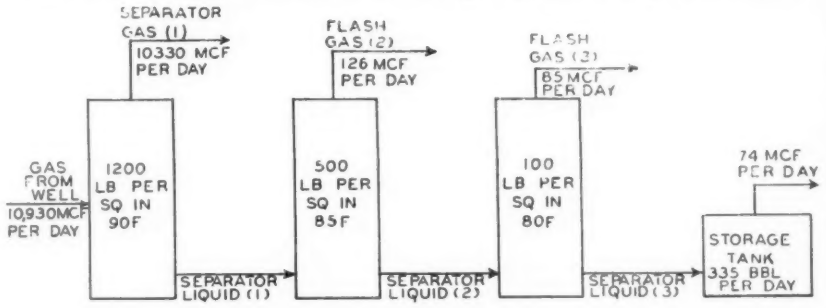
Plant processing is most efficient. Many of the plants in operation today of the absorption-oil type recover in excess of 30 per cent of the propane, 80 per cent of the butanes, and substantially all pentanes, hexanes, and heptanes and heavier.

● **Unitization.** There is now almost universal agreement that unitization of operating and royalty interests is an essential prerequisite for efficient operation of a gas-condensate reservoir. The primary purpose of unitizing operations is to increase recovery of condensate and other liquefiable hydrocarbons, resulting in increased values to the operator, the royalty owner, and society as a whole. In the foregoing sections of this review, unitization has been tacitly assumed in discussing operating methods.

Results of cycling operations have proved beyond doubt that the reservoir containing gas condensates is itself a unit, with no subsurface lease boundaries. The gas is freely migratory, and the amount of recovery from the reservoir is determined by the *location* of wells—not the number of wells. The *operating* method used is of primary importance, and it should be selected by study of the reservoir as a whole.

In cycling and other pressure-maintenance operations, the objective of efficient operation is to produce the gas condensate, but not to produce the dry gas, water, or other fluid that displaces the gas condensate from the reservoir. This can be done only by locating and operating wells to take advantage of structural position and other conditions in the reservoir. For most efficient operation, lease ownership should not be given any consideration. However, income must be shared by all leases, and not exclusively by those on whose tracts the producing wells are located. Unitization provides a means of equitably sharing the income.

FIG. 5. Diagrammatic sketch of multi-stage separation of gas-condensate.



A brief survey of differences between most oil and gas-condensate reservoirs may serve to clarify the more urgent need for unitized operation in the latter type of field. First, dollar recoveries per volume of the reservoir from gas condensate is much less than from oil. For instance, cycling yields on the order of 20 bbl to 200 bbl condensate, and 1,000 MCF to 4,000 MCF of gas per acre-ft, worth approximately $65 to $470 at prices of $1.75 per bbl and $0.03 per MCF, respectively. On the other hand, crude oil yields are on the order of 200 bbl to 1000 bbl per acre-ft, with possible small additional value for gas produced with the oil. Whereas a profit can be made in most cases by drilling an oil well to each 40 acres, the same is not true of gas condensate. Wider spacing of wells means that a well cannot be drilled on each and every lease and, therefore, units must be formed to prevent gross inequity of income. Second, extraction plants to strip efficiently the liquefiable hydrocarbons from gas condensate require large investments in addition to that for drilling the wells, and it is not often that one operator in a field has sufficient holdings to make the construction and operation of such a plant financially attractive. Third, the actions of one operator in a field affect the operations of all others because of the freely migratory character of gas. This effect is more noticeable in gas-condensate than in oil fields. Thus, one operator by selling gas can (and in some cases has done so) drop the pressure throughout a reservoir containing retrograde gas, resulting in damage to any lease wherein operators are maintaining pressure by gas or water injection.

The foregoing and many other advantages of unitized operation are recognized by all. It is beyond the scope of this review to outline all the arguments[10] for, or the few against, unitization. It is significant that some states require as a matter of law that, in the event a majority of interests in a gas-condensate field desire to unitize to enable more efficient operation, others also must do so. However, almost all the units formed up to now have been voluntary. Operators and royalty owners alike have been assured of an overall income under unitized operation greater than would be obtained by non-unitized operation. This usually can be demonstrated because of the fact that total recovery always is greater by unitized operation.

Even when all parties interested in a given field have agreed that unitization is desirable, the agreement upon a basis for participation in a unit is often difficult. The basic principle for participation in most units has been[6,12] that each party should share in the unit in the proportion that the recoverable hydrocarbons under his tract, or the value thereof, bears to the total under all tracts.

● **References**

1. "Application of Laboratory Data on Phase Behavior to Evaluation of Condensate Reserves," E. W. McAllister, *The Petroleum Engineer*, 17 (3) 90 (1945).
2. "Problems in High-Pressure Distillate Pools," E. V. Foran, *AIME Transactions*, 132, 22 (1939).
3. "Interpretation of Well-Test Data in Gas-Condensate Fields," J. O. Lewis, *Petroleum Technology (T. P. 2053)* July (1946).
4. "Phase Equilibria in High-Pressure Condensate Wells," F. V. L. Patten and D. C. Ivey, *Oil Weekly* 92 (1) 20 (1938).
5. "Condensate Wells—Completion and Recycling Operations," E. V. Foran and P. C. Dixon, *Drilling and Production Practice*, 340-47 (1939).
6. "Cycling Operations," H. H. Kaveler, *Oil Weekly* 123 (1) 33 (1946).
7. "Some Factors in the Economics of Recycling," Emby Kaye, *AIME Transactions*, 146, 221 (1942).
8. "The Application of Electrical Models to the Study of Recycling Operations in Gas-Distillate Fields," W. A. Hurst and G. M. McCarty, *A.P.I. Drilling and Production Practice*, 228-40 (1941).
9. "Significance of the Critical Phenomena in Oil and Gas Production," D. L. Katz and C. C. Singleterry, *A.I.M.E. Transactions*, 132, 103 (1939).
10. "Practical Economics of Cycling," B. B. Boatright and P. C. Dixon, *A.P.I. Drilling and Production Practice*, 221-7 (1941).
11. "Unitization—Its Progress and Future," D. R. Knowlton, *A.P.I. Drilling and Production Practice*, 630-34 (1939).
12. API Special Study Committee on Well Spacing and Allocation of Production, *Progress Report on Standards of Allocation of Oil Production Within Pools and Among Pools*, 3 (1942).

Taken from the article, "Gas-condensate reservoirs—a review," by O. F. Thornton, The Texas Company, published in *The Petroleum Engineer*, Reference Annual, 1947, pages 124 to 138, inclusive. This paper was presented before the annual meeting of the American Petroleum Institute, Chicago, Illinois, November 12, 1946.

Well — It's the WHOLE Truth . . .

DRISCOSE is a Driller's Mud!

- IT PROVIDES THIN BUT STRONG FILTER CAKES
- IT REDUCES WATER LOSSES
- DRISCOSE HELPS REDUCE WELL COSTS THROUGH BETTER COMPLETIONS

Write today for field data.

*DRISCOSE is our trade name for Carboxymethylcellulose

DRILLING SPECIALTIES COMPANY

BARTLESVILLE, OKLAHOMA

DRISCOSE

Thermoid changes

In line with its expanded sales and manufacturing program, Thermoid Company, Trenton, New Jersey, has announced the following personnel changes:

Jack Brand, formerly assistant sales manager for Thermoid's Automotive Replacement Division at Trenton, will handle industrial sales for the state of Colorado, with headquarters at Denver.

J. J. Chamberlain, formerly associated with Pioneer Rubber Mills of California and the Rubber Division of Paramount Manufacturing Company, will handle industrial sales in the state of Washington and the northern half of Oregon, with headquarters in Seattle.

E. J. Dunlap has been transferred from Trenton, New Jersey, where he headed industrial sales promotion, to San Francisco, California, where he will have charge of industrial sales for the northern half of California and southern Oregon.

A. Fred Matheis, who has been in industrial sales with Thermoid at Trenton headquarters for 20 years, assumes the duties of industrial sales promotion manager.

H. William Overman, manager, Industrial Friction Materials Division, has transferred his headquarters to the Thermoid office at 422 Boulevard Building, Detroit, Michigan. He will continue to direct industrial friction material sales from that office.

Jack Wright, who will make his headquarters at Salt Lake City, Utah, has been assigned industrial and oil field sales in Utah, Idaho, Wyoming, Montana, and Western Canada.

According to the company, its new manufacturing unit at Nephi, Utah, is, at the present time, undergoing pilot runs. Full production is anticipated early next year.

Director of research

Announcement has been made by American Car and Foundry Company that Jerry M. Gruitch has been appointed director of research and development as of December 1. Gruitch has had a long and distinguished career in the field of engineering and research. He holds the degree of B.S.M.E. from the University of Michigan and M.M.E. from the Chrysler Institute of Engineering. He is also a registered professional engineer and a member of Tau Beta Pi, Society of Automotive Engineers, American Society of Refrigerating Engineers, and The American Society of Heating and Ventilating Engineers.

J. M. Gruitch

100th anniversary

Coinciding with the greatest period of U. S. industrial development, Allis-Chalmers this year completes a 100-year record of engineering and manufacturing that has produced a most diversified line of major industrial products.

Started in 1847 by Charles Decker and James Seville, two Ohioans, as a finisher of French burr millstones to help equip the mills that were soon to make Milwaukee the upper Great Lakes' leading wheat and flour market, Allis-Chalmers represents an organization formed from 16 separate firms that today is supplying more than 1600 different products to industries all over the world.

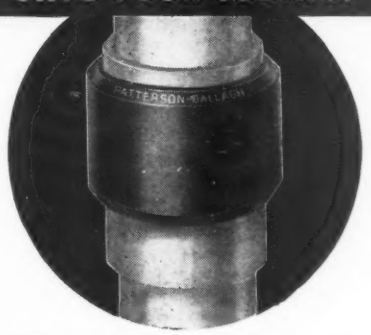
This giant producer of power generation, power distribution, and power utilization equipment was conceived by Edward P. Allis, a native of Cazenovia, New York, who with two other men, acquired Decker and Seville in 1861. It was Allis who established the renowned company policy of diverse manufacture—adding new products and services to meet the changing requirements of a wide range of industries.

Paralleling the growth of a great industrial era, Allis-Chalmer has pioneered in many fields. The Edw. P. Allis and Company's early history is one of expansion in the fields of steam power, pumping, flour milling, and saw milling. It was a period of new developments by outstanding engineers. R. W. Hamilton, for example, conceived the plans for the nation's first steam driven vertical-reciprocating pumping engines which were installed in 1874 in Milwaukee. W. D. Gray, prominent milling engineer, introduced the roller or gradual reduction process of milling flour into America in 1876. George M. Hinkley noted saw mill engineer, was responsible for the Hinkley-designed band-mill first put on the market in 1885. Edwin Reynolds, distinguished engineer, in 1878 offered the world an improved Reynolds-Corliss engine.

Sales conference

Sales representatives of Well Equipment Manufacturing Corporation held a three-day meeting at the Houston plant beginning December 4, during which they discussed Okadee and Anchor products, G. R. Winder, Weco vice president and sales manager, announced.

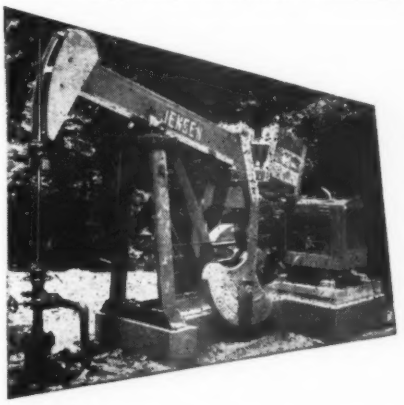
"Best Bet Yet"
SAVE YOUR TUBING!



Tubing collars worn by contact with casing steal the profit out of pumping. Patterson-Ballagh Plastic Tubing Protectors prevent both collar and casing wear. Oil-proof, wear-resistant, insulating. They are pressed onto the collar under pressure and will not come off. Made in all sizes. End your tubing troubles. CALL in your Patterson-Ballagh man.

Specify "Best Bet Yet"
PATTERSON-BALLAGH
A Division of Byron Jackson Co.
PLASTIC
TUBING PROTECTORS

190 E. 65th Street, LOS ANGELES 1
6247 Navigation Blvd., HOUSTON 11
931 Russ Bldg., SAN FRANCISCO 4
808 Graybar Bldg., NEW YORK 17



A JENSEN is the Right Answer

When choosing pumping units ask yourself these questions:

Is the cost "in line"?
Is the unit of proven dependability?
Will spare parts be available?
Low maintenance costs?
How long has the manufacturer been in business?
Does he stand behind his product?

For 28 years, producers who stop to think before buying answer these and lots of other questions with one word—JENSEN. See your Jensen dealer or write us for the right answer in pumping any well from any depth.

JENSEN
BROTHERS MFG. CO.
COFFEYVILLE, KANSAS, U. S. A.
EXPORT OFFICE, 50 Church St.
New York City

MORE
Horsepower
Per Boiler
Where

SAND-BANUM

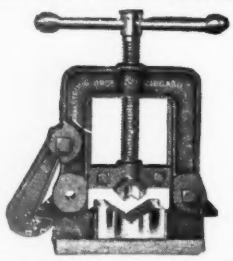
Is Used for the

automatic removal and prevention of scale and corrosion while your equipment operates.
Requires no expert handling — comes ready to use as is — all active ingredients.

For More Power With Less Fuel WRITE TODAY for the Facts

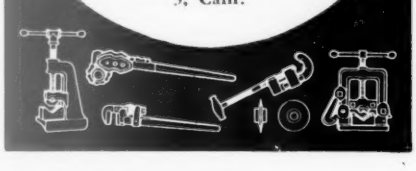
"The Entirely Different Boiler and Engine Treatment"

AMERICAN SAND-BANUM COMPANY, Inc.
9 ROCKEFELLER PLAZA,
NEW YORK CITY 20



"ARMSTRONG BROS." Pipe Vises are built for lifetime service with *unbreakable* drop forged steel hooks. Other design improvements include: oval handle ends (will not pinch hands), replaceable tool steel jaws with milled teeth, and on sizes 70 and 71, a solid 1-piece jaw that prevents kinking of small pipe. There are always extra quality features in an "ARMSTRONG BROS." Pipe Tool.

ARMSTRONG BROS. TOOL CO.
5231 West Armstrong Ave., Chicago 30, U. S. A. Eastern Whse. and Sales: 199 LaFayette St., New York 12, N. Y. Pacific Whse. and Sales Office: 1275 Mission St., San Francisco 3, Calif.



Buy plant addition

Economy Pumps, Inc., Hamilton, Ohio, has acquired from the War Assets Corporation the wartime addition to its plant, built by the Defense Plant Corporation. The addition was built in 1942 at a cost of $705,000, to house an Economy subsidiary, Liberty Planers, Inc.

The new building contains 100,000 sq ft in five parallel crane bays, served by 30, 15, 10, 5, and 3-ton cranes, together with land for future expansion. A Baltimore and Ohio RR switch spur for five cars enters the building.

The Economy firm manufactures centrifugal, axial flow, and mixed flow type pumps in a wide range of sizes up to 150,000 gpm. Test equipment in the plant is capable of performance tests up to 30,000 gpm.

The new plant will house both of Economy's subsidiaries, Liberty Planers, Inc., and the Klipfel Manufacturing Company, which produces automatic regulating valves.

Sullivan promoted

Appointment of Joseph A. Sullivan as manager, Advertising Bureau, Universal Atlas Cement Company, was announced by George H. Reiter, vice president of this United States Steel subsidiary. Sullivan has also been appointed director of public relations. He succeeds Max A. Berns, publicity manager, deceased.

Web Wilson appoints

Web Wilson Oil Tools, Inc., has announced the appointment of Defee and McKernan as their agents for the sale and servicing of Web Wilson Oil Tools in the West Texas and New Mexico areas. Headquarters will be at Odessa, Texas, where ample stocks of Web Wilson equipment will be warehoused.

J. M. "Jimmie" Defee has had approximately 12 years of oil field experience in the West Texas area including actual field experience as a roughneck and driller. He was connected with the Green Head Bit and Supply Company for about three years and for the past year was associated with Patterson-Ballagh in West Texas.

C. J. "Chili" McKernan is a well seasoned oil field equipment man. He was with the Wilson Supply Company in the Gulf Coast area and for the past year has been with Patterson-Ballagh in West Texas. He spent 3½ years in the Army Air Corps and was discharged as a captain.

Heads division

Dan M. Rugg, vice president and general manager of the Chemical Division of Koppers Company, Inc., announces the appointment of B. J. C. van der Hoeven as assistant general manager of the division. The appointment is effective at once. The position is a newly created one in Koppers expanding Chemical Division.

During the war van der Hoeven was manager of operations of the Kobuta, Pennsylvania, styrene and butadiene plant that was built and operated by Koppers for the government. Since early last year, he has been chief of the company's Chemical Engineering Department, Engineering and Construction Division.

Hilco representatives

Appointment of new representatives to handle the line of Hilco lubricating, fuel, and industrial oil purifying equipment is announced by T. A. LaBrecque, manager of the Oil Purifier Division of The Hilliard Corporation, Elmira, New York. The new representatives are:

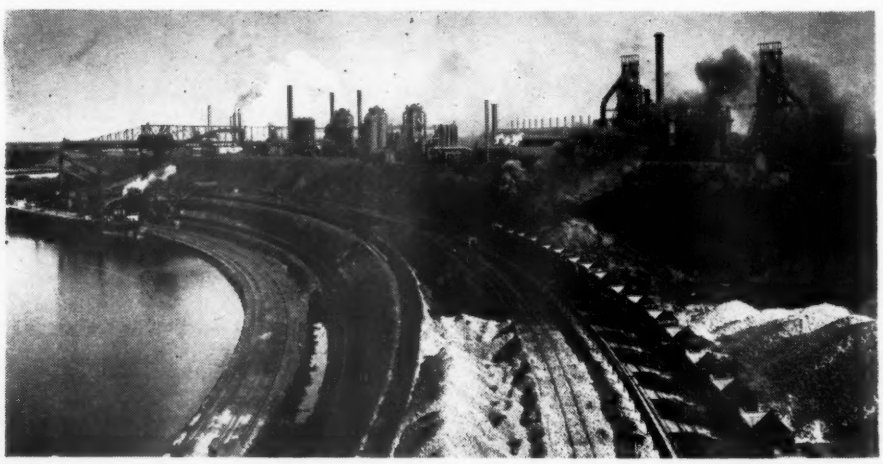
Hucker Sales Company, 1700 Walnut Street, Philadelphia 3, Pennsylvania.

R. T. Whitson and Son, 723 Transportation Building, Cincinnati 2, Ohio.

L. M. Sands and Company, 246 Ritch Street, San Francisco, California, to operate in the State of California.

R. E. Chase and Company, Tacoma Building, Tacoma 2, Washington, to operate in the Washington and Oregon area.

Expanding National Tube Company plant



Complete renovation of this dock on the Black River at Lorain, Ohio, where iron ore arrives from Minnesota, is one of the first-to-be-finished improvements in the $100,000,000 modernization and expansion program of U. S. Steel's National Tube Company plant there. The Lorain program includes a new coke plant, the first continuous seamless pipe mill ever built, modern blooming, bar and billet mills, an entirely new Bessemer steel plant and a three-acre warehouse. The project is part of the $500,000,000 expansion that U. S. Steel has well under way.

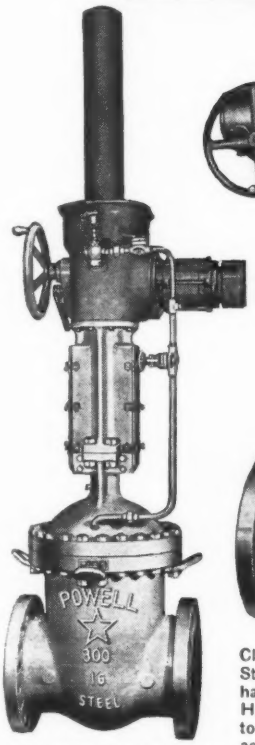
POWELL makes a *complete* line of valves designed for OIL REFINERIES

More than a century ago, the Wm. Powell Company adopted a definite, long-range policy, namely, to concentrate on making valves—and valves only—for all branches of industry. As a result Powell has been able, through the years, to meet each new flow control requirement as it has arisen. Thus at any given time in more than a hundred years, the Powell Line has always been *complete*.

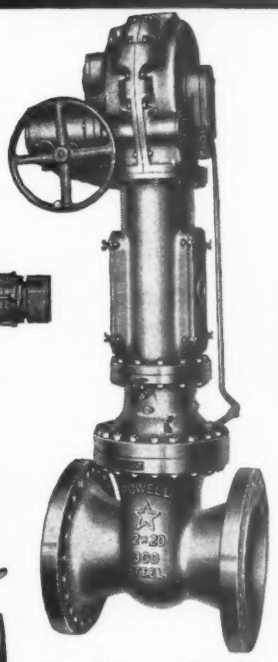
As of today, the Powell Line includes Bronze and Iron Valves of all required types, designs and sizes; Cast Steel Valves of all types in pressure classes from 150 to 2500 pounds; and Valves for Corrosion Resistance, available in the widest range of metals and alloys ever used in making valves.

The Wm. Powell Co., Cincinnati 22, Ohio

DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

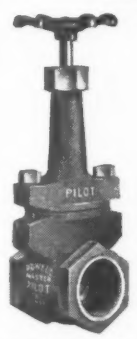


Class 300-pound Cast Alloy Steel Gate Valve with automatic steam sealing mechanism and explosion proof electric motor operator.

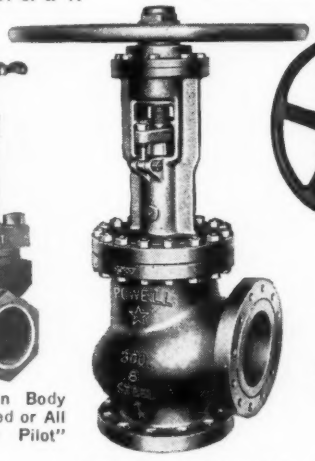


Class 300-pound Cast Alloy Steel Gate Valve, built to handle high temperatures. Has 12" port size venturied to 20" size end flanges to accommodate insulated pipe. Has explosion-proof electric motor operator.

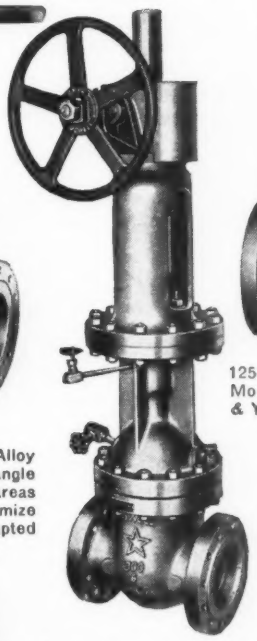
Large 125-pound Iron Body Bronze Mounted or All Iron O. S. & Y. Gate Valve.

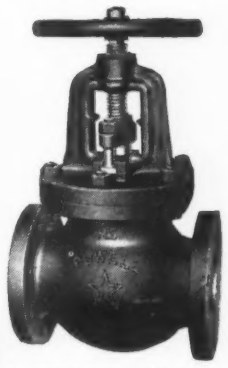


125-pound Iron Body Bronze Mounted or All Iron "Master Pilot" Gate Valve.

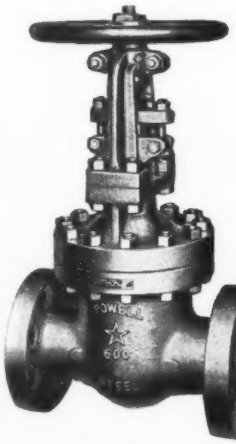


Class 300-pound Cast Alloy Steel O. S. & Y. Angle Valve. Streamlined areas through the body minimize pressure drop. Adapted for high temperatures.

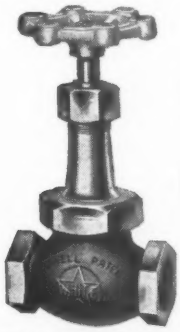




125-pound Iron Body Bronze Mounted or All Iron O. S. & Y. Globe Valve.

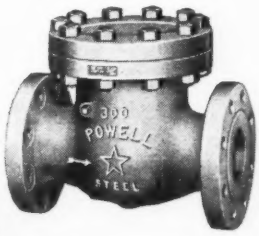


Class 600-pound Cast Steel O. S. & Y. Gate Valve.



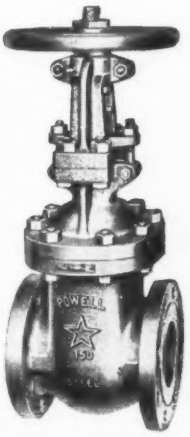
200-pound Bronze Globe Valve with renewable stainless steel seat and regrindable, renewable, wear-resisting "Powellium" nickel-bronze disc.

200-pound Bronze Gate Valve with renewable "Powellium" nickel-bronze disc.



Class 300-pound Cast Steel Swing Check Valve.

Class 300-pound Cast Alloy Steel Gate Valve for ultra-high temperatures as in T. C. C. Has drain valves in stuffing box and bonnet and cooling fins to dissipate the heat. Gear operated.



Class 150-pound Cast Steel O. S. & Y. Gate Valve.

POWELL VALVES

Continental president

The election, effective December 1, of Leonard F. McCollum, formerly coordinator of producing activities of Standard Oil Company of New Jersey, as president of Continental Oil Company, was announced recently at the company's offices in New York. Resignation of Dan Moran as president of the company was announced at the same time. Moran relinquished the duties of his office because of ill health but the company will continue to have the benefit of his advice in a consulting capacity.

L. F. McCollum

McCollum was born in 1902 in Bradford, Tennessee, and received his early education in the public schools of Fordtran and Cuero, Texas. He attended Texas University for one year and then worked for the Swift Packing Company at Yoakum and Houston, Texas, until 1922 when he reentered the university. He majored in geology and was graduated in 1925 with a bachelor of arts degree. After graduation McCollum joined the Humble Oil and Refining Company, an affiliate of Standard Oil Company of New Jersey, serving as a geologist in the company's operations at Amarillo and San Antonio. In 1934 he was assigned to the Carter Oil Company as chief geologist and manager of exploration and later became president.

In 1943, the parent company sent McCollum to New York as its assistant coordinator of producing activities. A year later he was made coordinator of the world wide operations of the company.

Moran's connection with Continental Oil Company dates back to 1928 when he became president of Marland Oil Company. Under his direction the company was completely reorganized and its name was changed to its present title following the acquisition of the assets of Continental Oil Company of Maine in 1929. Throughout the period of his association with Continental, Moran concentrated his efforts on the development of its crude oil reserves and has built up for himself an enviable record.

Gar Wood appointments

Stepping up the tempo of its sales and manufacturing, Gar Wood Industries, Inc., with executive offices at Wayne, Michigan, has integrated its organization to meet the continuing heavy demand for construction equipment.

W. H. Hammond, vice president-sales announces the appointment of E. B. Hill as general sales manager and R. F. Whitworth, general service manager and the creation of four domestic regional sales offices under Hill. Promoted to regional managers are Ross Miller, San Francisco (Western Region), A. C. Berg, Wayne, Michigan (Central Region), W. G. Barrett, Boston (Northeast Region) and H. C. Hatch, Washington, D. C. (Southeast Region).

Concurrent with the establishment of regional offices, Gar Wood Industries, Inc., has consolidated its operations into three basic divisions. The Findlay Division, Findlay, Ohio, will assume the manufacture and distribution of Gar Wood tractor equipment, the Wayne Division, Wayne, Michigan, will continue to manufacture and distribute Gar Wood truck equipment, and the St. Paul Division, Minneapolis, Minnesota, will manufacture and distribute St. Paul hoists, bodies, and truck patrols.

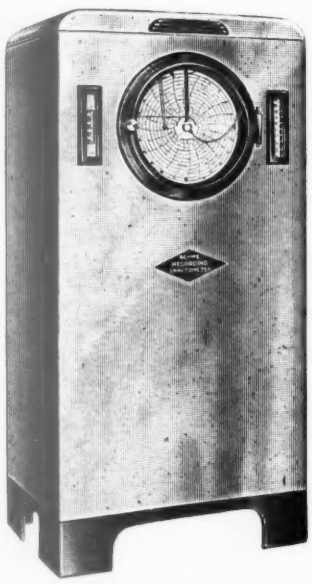
J. D. Towne has been appointed division manager and W. S. Blakeslee was promoted to sales manager of the Wayne Division.

Promotions to district manager were also announced for H. N. Nelson, B. A. Cooper, E. R. Curry, W. D. Kerrick, R. J. Palmer, R. M. Steegman, D. C. Royce, and W. R. Karll.

Branch manager

The appointment of Harold J. Fikejs as manager of the Mack Truck Company's Milwaukee direct factory branch is announced by A. C. Fetzer, Mack vice president and general sales manager.

Fikejs, who at 31 is one of the youngest men in the company's history to hold a branch managership, has served Mack as truck salesman and district wholesale manager at the Des Moines branch since he joined the company in 1946, after four years with the Army.



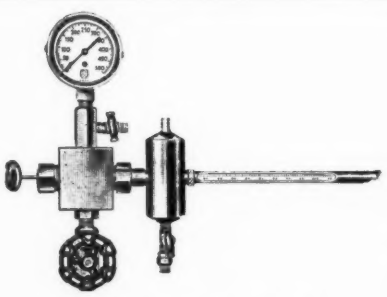
AC-ME RECORDING GRAVITOMETER

COMPLETE VISIBILITY
EXTREMELY SENSITIVE

This instrument accurately records the changing gravity of gas and automatically corrects for variation in barometric pressure and temperature.

Sturdy construction and simplicity of operation contribute to accurate operation with a minimum of maintenance.

The instrument does not contain rotating parts thereby eliminating a major source of wear. The accuracy and practicability of Refinery Supply Company equipment are the result of scientific and sound manufacturing procedures combined with materials of proven integrity.



DEW POINT TESTER

Simple to operate. Dew points can be determined with an accuracy of 0.2F., even on high pressure gas transmission lines. Standard range is 0 to 500. P.S.I.

Complete Line of Scientific Laboratory Equipment

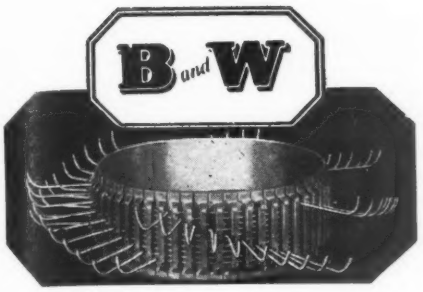
Write for Catalog No. 30-A

THE REFINERY SUPPLY CO.

Main Office and Plant

621 East 4th Street — **TULSA 3, OKLAHOMA** — Phone 4-8144

Houston Office Temporarily Discontinued



PATENTED AND PATENTS PENDING

B & W Wall Cleaning Guides prevent channeling . . . . the greatest single cause of cementing failures.

DON'T SQUEEZE!

It Can Be Avoided.

BRUCE BARKIS — B and W INCORPORATED — KENNETH WRIGHT

Well Completion Specialists

HOUSTON, TEXAS • LONG BEACH, CALIF.

WANTED
PETROLEUM OR CHEMICAL ENGINEERS

Degree necessary. Engineering experience not necessary. Single men preferred. Excellent opportunity for training and advancement in Petroleum Reservoir Engineering in all major producing areas. Apply by letter stating education, experience, and marital status to

CORE LABORATORIES, INC.
BOX 5810 DALLAS, TEXAS

WANTED: Pipeline Engineer with Engineering degree. Previous experience of from five to ten years in gas pipeline design construction or operations; must know design of pipelines in compressor stations. Salary commensurate with experience and ability. Position offers unlimited opportunity in young, progressive company. Please furnish references and full particulars regarding education, qualifications and other personal data necessary for proper appraisement. Our employees have been informed of this advertisement. Address Box 75, c/o THE PETROLEUM ENGINEER, P. O. Box 1589, Dallas, Texas.

WANTED: Process engineer with degree in Chemical Engineering. Must have working knowledge of natural gasoline plants, refineries and chemical processes. Salary commensurate with experience and ability. Position offers unlimited opportunity in young, progressive company. Please furnish reference and full particulars regarding your education, qualifications and other personal data necessary for proper appraisal. Our employees have been informed of this advertisement. Address Box 74, c/o THE PETROLEUM ENGINEER, P. O. Box 1589, Dallas, Texas.

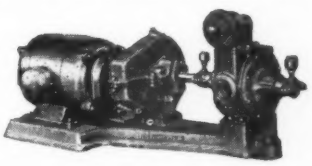
HELP WANTED . . . PROCESS ENGINEER technically trained and experienced in natural gas processing design. Work will include plants for Absorption, Dehydration, Purification, Compression, etc. Permanent location Denver, Colorado. Communicate directly with Stearns-Roger Mfg. Company, 1720 California St., Denver, Colorado.

SITUATIONS OPEN: Chemical Engineers with three to five years' experience in the operation of petroleum refining distillation units, thermal cracking units or catalytic cracking units for work as Technical Service representatives and Operators of commercial catalytic cracking plants. Kindly send details of experience and education. Snapshot (if available). Address Box No. 59, % *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

PUMPS *for the* **PETROLEUM INDUSTRY**

Write for Bulletin No. 102 which shows why and how

BLACKMER PUMPS
are SELF-ADJUSTING FOR WEAR

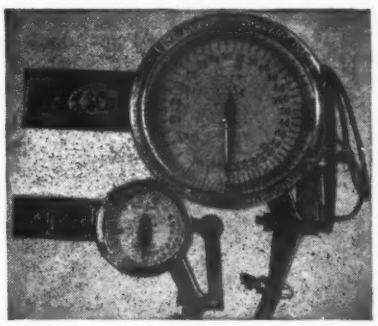


Gathering Pumps • Refinery Pumps
Bulk Station and Truck Pumps
Hand Pumps • Suction Line Strainers
Capacities to 750 GPM

BLACKMER PUMP COMPANY
1980 Century Avenue Grand Rapids 9, Mich.

SERVING THE PETROLEUM INDUSTRY FOR 40 YEARS

LINE SCALES



(Above) Super 500,000-lb. capacity, 14" dial. (Below) Packer Special, Capacity 40,000 lbs., 6" dial. 18 other models for every drilling, well servicing, or work-over need.

20 MODELS to choose from

With a LINE SCALE you know the pull on the line, and the weight on the bit in pounds. Repeated tests prove the accuracy and dependability of LINE SCALE readings under all working conditions . . . even in areas of rapid temperature changes.

LINE SCALE CO., Inc.
Box 4245 Oklahoma City Phone 6-1765
Gulf Coast Representative: Hiram Wheeler
Box 8043, Houston 4, Texas—J2-1107

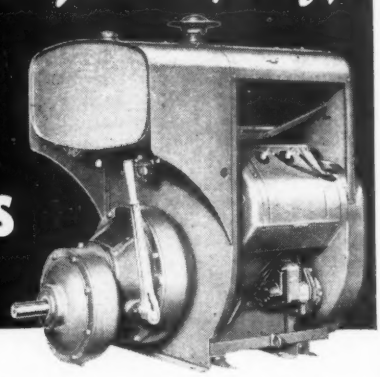
For Your Tough Power Jobs, Specify

WISCONSIN

HEAVY-DUTY

4 CYL. V-TYPE

***Air-Cooled*-ENGINES**



Here is a 475-lb. power package that delivers 30 hp. at 2000 R.P.M. — designed and built for dependable, heavy-duty service outdoors or indoors. It's the Model VP-4, V-type, 4-cylinder Wisconsin Air-Cooled Power Unit.

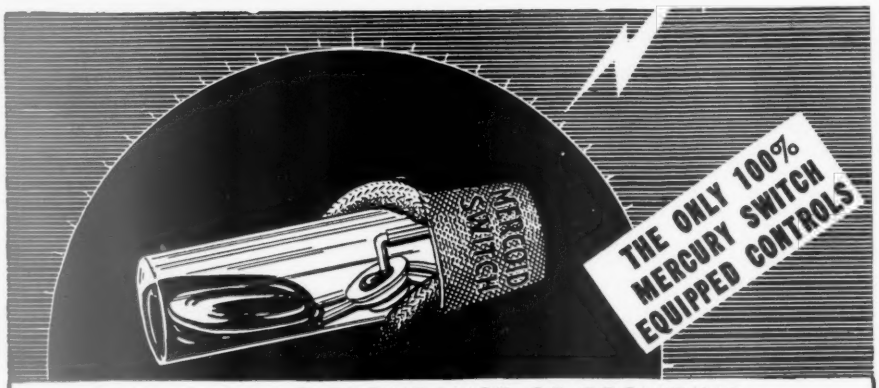
Compact V-type design simplifies installation on a great variety of equipment and efficient AIR-COOLING takes care of all cooling problems . . . at any season, in any location.

Heavy-duty engineering features include: Tapered roller main bearings, dynamically balanced crankshaft, mirror-finish crank-pins, honed cylinders, and molybdenum iron valve seat inserts. High tension rotary type outside magneto is equipped with Impulse Coupling for quick, easy starting in any weather.

For utmost dependability . . . specify "Wisconsin Engine". Supplied in a complete power range from 2 to 30 hp., 4-cycle, single cyl. and V-type 4-cyl. models.

WISCONSIN MOTOR
Corporation
MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
510 Atlas Building, Tulsa, Oklahoma
M & M Building, Houston, Texas
Oil field distributors for Wisconsin Engines and all types of utility units.



IT HAS THE ENDURANCE OF PROVIDING

MILLIONS

OF "MAKES" AND "BREAKS" IN THE ELECTRICAL CIRCUIT

The mission of a Mercoid Mercury Switch in an automatic control is to assure longer life and greater dependability—minimizing the need for attention after the control is in service. Mercoid Controls lend themselves to quick installation and adjustment, all of which are invaluable contributions in a time of national crisis.

Mercoid Switches, the distinguishing feature, used exclusively in all Mercoid Controls, are especially designed types of hermetically sealed mercury switches. They are not affected by dust, dirt, moisture or corrosive gases, nor are they subject to open arcing, oxidation, pitting or sticking of contacts—common causes of trouble.

Keep these important facts in mind when selecting automatic controls.

MERCOID CONTROLS

FOR HEATING, AIR CONDITIONING, REFRIGERATION, AND INDUSTRIAL APPLICATIONS

THE MERCOID CORPORATION, 4205 BELMONT AVE., CHICAGO 41, ILL.

Works manager

Appointment of J. D. Isaacks to the position of works manager has been announced by Stanley J. Roush, executive vice president of Kerotest Manufacturing Company, Pittsburgh, Pennsylvania. A greatly expanded program in the production of Kerotest pipe line and refinery valves to meet current oil country developments is linked with the appointment of Isaacks who has been prominent in oil country circles both in California and the Southwest for many years as division manager for Kerotest headquartering in Houston, Texas.

J. D. Isaacks

Isaacks has been associated with Kerotest Manufacturing Company for more than 14 years.

Scholarship plan

The National Supply Company has announced a new scholarship plan, effective immediately, to provide financial opportunity for employes who desire to improve in their jobs and qualify for better positions with the company.

Under the plan, all full-time employes with six months' continuous service are eligible to participate. This includes employes in the company's offices, sales divisions, the six plants at Etna and Ambridge, Pennsylvania, Toledo and Springfield, Ohio, Torrance, California, and Houston, Texas, and in its many retail stores in the oil fields.

The plan provides that the company will refund one-half the tuition paid by any eligible employe upon satisfactory completion of any course of study taken from an approved trade school, college, or by correspondence. The company will make refunds up to $100 per employe in any calendar year.

Dr. B. E. Warden, educational director of the company, said that all courses of study under the plan must be approved in advance by a responsible official of the company, as contributing to the best interest of the employe and the company.

Veterans who are eligible under the GI Bill for full tuition payments, may participate in the scholarship plan after their payments from the Veterans Administration are exhausted.

Manufacturing rights

On his recent trip to Europe, Elmer J. Weis, vice president of Pacific Pumps, Inc., Huntington Park, California, completed an agreement with the Pulsometer Engineering Company, Ltd., Reading, England, for the manufacture of the Pacific centrifugal line for distribution throughout Europe and the Near East.

The British company has the sole rights to manufacture at its Nine Elms Iron Works, Reading, the complete range of pumps which Pacific Pumps, Inc., have for many years supplied for oil refineries and oil field services.

Joins Delaney Company

The Delaney Company, Houston, Texas, manufacturers of forged steel well heads, Christmas tree fittings and other oil well drilling and completion specialties, has announced the appointment of B. V. Fisher as sales manager of its oil field division.

B. V. Fisher

Mr. Fisher is widely known in the oil industry, having only recently vacated the position of executive vice president of Oil Center Tool Company, a firm which he has served in various executive positions for the past eleven years. Prior to that time he was connected with the Continental Supply Company and the Westcott Valve Company.

Mr. Fisher is a member of the Houston Chapter of Nomads and has long been active in the Association of Well Head Equipment Manufacturers, the Petroleum Equipment Suppliers Association, and the American Petroleum Institute.

NGAA committee

Frank M. Perry, Cities Service Oil Company, Bartlesville, Oklahoma, is to head the convention program committee for the 27th annual convention of the Natural Gasoline Association of America, according to a recent announcement by NGAA President C. R. Williams, The Chicago Corporation, Corpus Christi. The convention is scheduled for March 24-26 at the Texas Hotel, Fort Worth.

Other members of the committee appointed by Williams are: Henry M. Brown, Midland Gasoline Company, Houston; J. H. Dunn, The Shamrock Oil and Gas Corporation, Amarillo; T. R. Goebel, Shell Oil Company, Inc., Houston; J. A. LaFortune, Warren Petroleum Corporation, Tulsa; John F. Lynch, La-Gloria Corporation, Corpus Christi; Albert H. Weil, United Pipe Line Company, Shreveport.

Technical service

A complete line of chemicals for industrial water conditioning and fuel oil treatment, in a full variety of forms—powder, liquid, colloidal, or briquette—are now available in Mexico from The Bird-Archer Company through its technical representatives, Calderas y Accessorios, Amsterdam 291, Mexico D. F.

Angel Noriega, general manager of the Mexican firm, has announced that Calderas y Accessorios have established a complete technical service in Mexico to facilitate the sale and service of Bird-Archer chemicals. Calderas y Accessorios is staffed with experienced technical men who are prepared to study and prescribe for industrial water and fuel oil treatment problems.

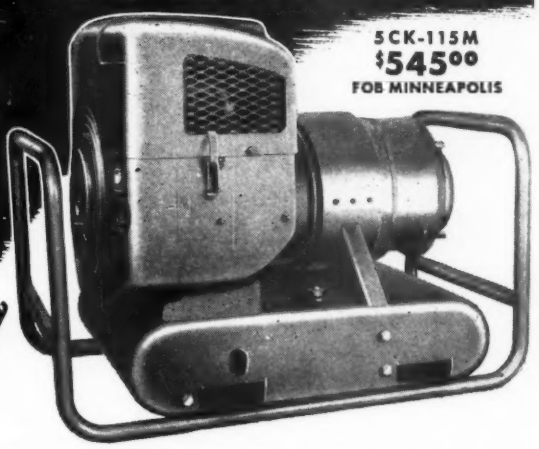
The Mexican firm now has laboratory facilities for the scientific analysis of samples, enabling them to offer a continuous control over treatment systems after they are put into effect.

New HEAVY-DUTY ELECTRIC PLANT

5000 WATTS

Only 272 lbs!

5CK-115M
$545.00
FOB MINNEAPOLIS



• Large capacity, compact design, and lightweight aluminum construction are combined in this new, rugged, portable electric plant. Easily carried by two men. Powered by Onan 10 HP horizontally-opposed, two-cylinder, 4-cycle, air-cooled engine. Unusual operating economy. Shipped complete, equipped with four-receptacle outlet box and mounted in tubular-steel guard frame.

NEW ONAN CK ELECTRIC PLANTS are available in 5,000 Watts D.C., 115 and 230 volts; 2000 and 3000 Watts A.C. in all standard voltages.

ONAN ELECTRIC PLANTS—A.C.: 350 to 35,000 Watts in all standard voltages and frequencies. D.C.: 600 to 15,000 Watts, 115 and 230 Volts. Battery Chargers: 500 to 6,000 Watts, 6, 12, 32 and 115 Volts.

ONAN AIR-COOLED ENGINES—CK: 2-cylinder opposed, 10 HP. BH: 2-cylinder opposed, 5.5 HP. IB: 1-cylinder, 3.25 HP.

Onan PRODUCTS

Write for Catalog

D. W. ONAN & SONS INC.
2759 Royalston Ave., Minneapolis 5, Minn.

ONAN ELECTRIC PLANTS

COOLING TOWER WATER

For cooling—or any use in any part of the Petroleum processing or pumping industry, Layne Well Water Systems produce large quantities of water at an extremely low cost.

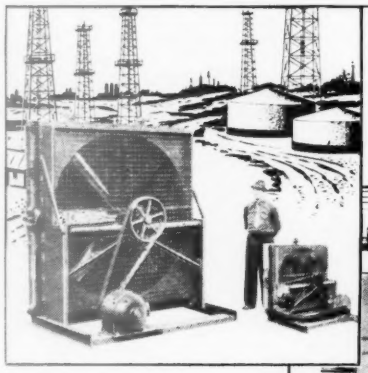
These Systems are scientifically engineered to have the rugged quality that assures extra long life, and freedom from expensive upkeep cost.

Any size—any capacity—against any head, Layne Well Water Systems always give peak performance. For further interesting details and facts, address Layne & Bowler, Inc., General Offices, Memphis 8, Tennessee.

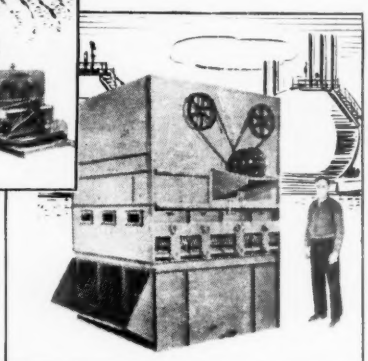
LAYNE Well Water Systems
VERTICAL TURBINE Pumps

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. • Layne-Atlantic Co., Norfolk, Va. • Layne-Central Co., Memphis, Tenn. • Layne-Northern Co., Mishawaka, Ind. • Layne-Louisiana Co., Lake Charles, La. • Louisiana Well Co., Monroe, La. • Layne-New York Co., New York City • Layne-Northwest Co., Milwaukee, Wis. • Layne-Ohio Co., Columbus, Ohio • Layne-Pacific, Inc., Seattle, Washington • Layne-Texas Co., Houston, Texas • Layne-Western Co., Kansas City, Mo. • Layne-Western Co. of Minnesota, Minneapolis, Minnesota • International Water Supply, Ltd., London, Ontario, Canada • Layne-Hispano Americana, S. A., Mexico, D. F.

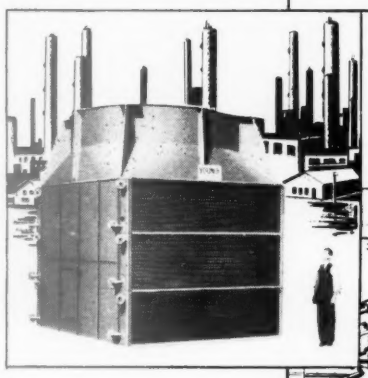
FOUR FAVORITES FOR COOLING
from Well to Refinery



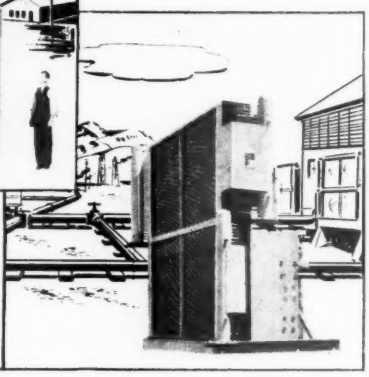
Jacket Water Coolers



Evaporative Coolers



Vertical Air Discharge Coolers



Atmospheric Gas Coolers

Wherever there are oil fields or refineries, you'll find Young Heat Transfer Products assigned to vital cooling tasks. In most every instance these applications are of a highly specialized nature and involved many hours of research and engineering on the part of Young factory and field men. When you are confronted with a problem in cooling, take it to the men whose job it is to produce efficient, economical results.

YOUNG

HEAT TRANSFER PRODUCTS

OIL COOLERS • GAS, GASOLINE, DIESEL ENGINE COOLING RADIATORS • HEAT EXCHANGERS
INTERCOOLERS • EVAPORATIVE COOLERS • ENGINE JACKET WATER COOLERS
GAS COOLERS • UNIT HEATERS • CONVECTORS • CONDENSERS • AIR
CONDITIONING UNITS • EVAPORATORS • HEATING COILS • COOLING COILS
AND A COMPLETE LINE OF AIRCRAFT HEAT TRANSFER EQUIPMENT

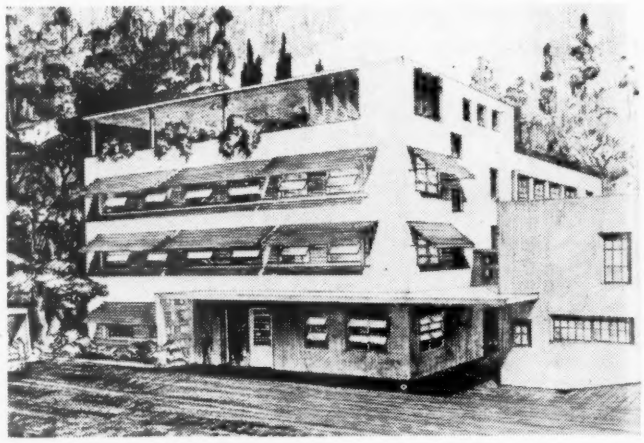
YOUNG RADIATOR CO. Dept. **RACINE, WIS., U.S.A.**

OIL FIELD DISTRIBUTORS

Mid-Continent Area: The Happy Company, Drawer 770, Tulsa 1, Oklahoma
West Coast Area: A. R. Flournoy Co., 5043 Santa Fe Ave., Los Angeles, Calif

Plant addition for Beckman Instruments

National Technical Laboratories, manufacturers of Beckman pH instruments, Spectrophotometers, and other advanced control equipment, has again expanded its facilities to meet the steadily increasing demand for its products. It recently completed a new addition to its modern offices and plant in South Pasadena, California. The new addition, a Class A reinforced concrete structure, is four stories high with a floor space in excess of 27,000 sq ft. Costing more than a third of a million



dollars, the new building embodies every modern advancement for highest manufacturing efficiency and personnel convenience, and features many unique developments for the volume production of highly precise instruments. This new building, plus space in the original building at the main plant and two other plants in South Pasadena, provide four separate buildings with approximately 60,000 sq ft of floor space devoted to the development and manufacture of the various Beckman instruments.

J & L construction program

Jones and Laughlin Steel Corporation has announced full details of a plant improvement program now under way entailing the investment of more than $100,000,000, of which $65,000,000 is yet to be spent. The program covers all departments of the corporation and the projects, with one exception, are scheduled to be completed by the end of 1949.

Announcement of the program was made by Ben Moreell, chairman of the board of directors and president, in a letter to the corporation's shareholders and employes in which he also explained that the program involves the sale of $60,000,000 first mortgage bonds.

"We believe this program will enable the corporation to improve its competitive position in the industry, which naturally is of vital concern to every shareholder and employe," he said. "While the program provides for some increase in steel making capacity, it is primarily for the purpose of improving the quality of our products and achieving reductions in cost."

Every consideration was given to the possibility of a major expansion in the corporation's steel making capacity, Admiral Moreell cited, but in view of the cost of such an expansion and the essential priority of the program now under way it has been deemed necessary to proceed with this program as the maximum undertaking advisable for the present.

It was pointed out, however, that constant studies of the long-range position of the corporation in the industry are being made, including analysis of raw material treatment, steel making, steel finishing, and the development of future markets. These studies are being made with a view to formulating plans for further improvements when conditions are considered appropriate.

Export distributor named

The Unit Rig and Equipment Company, Tulsa, Oklahoma, has announced the appointment of the Mid-Continent Supply Company, Inc., 42 Broadway, New York City, as exclusive export distributors of its entire line of oil field equipment.

S. M. Jones Company moves offices

The S. M. Jones Company, Tulsa, Oklahoma, has announced removal of its officers to Rooms 924-925-926 Kennedy Building.

Big butane storage tanks

The loading onto two railroad flat cars, and the delivery of the giant sized butane storage tanks now nearing completion at the Butane Equipment Company plant in Dallas is an interesting spectacle. These large tanks, 11 ft in diam by 63 ft 5 in. in length, have a 45,000-gal water capacity.

The big tank pictured here is the first of seven to be constructed at the Dallas plant of the Butane Equipment Company, Inc. The tanks are being constructed for the Lummus Company,

New York City, refinery construction engineers, and are to be used by the Barnsdall Oil Company of Tulsa. The seven tanks will be shipped to Barnsdall at Benton, Louisiana.

Standing inside the large tank are John W. Pratt, left, petroleum engineering department; Albert D. White, manager of the company, and Bazil Noble, assistant manager and director of production.

Saran pipe and fittings distributor

It is announced that Saran Lined Pipe Company, a newly organized firm, will act as exclusive distributors for The Dow Chemical Company's recently developed specialty pipe and fittings.

The pipe and fittings, lined with Saran, a Dow plastic, was developed for use where highly corrosive materials are handled in manufacturing processes.

Chemical resistance, ease of fabrication, immediate delivery, and reasonable cost are among the pertinent advantages of the new product, Dow reported.

S. H. Blackmore, sales manager of the Saran Lined Pipe Company whose offices are in the Stephenson Building, Detroit, said that his firm plans to establish sales representatives and jobber outlets to handle the product throughout the country. The pipe and fittings are now in production at Dow's Midland plant and are immediately available, he said.

Corrosion engineers meet

At a meeting held in Dallas, Texas, November 20, corrosion engineers of the North Texas area formed a temporary organization and voted to petition the National Association of Corrosion Engineers for recognition as the North Texas Section of that body.

Temporary officers were elected, with T. R. Statham of the Magnolia Pipe Line Company, Dallas, chairman, James A. Clay, Jr., Service Engineers, Fort Worth, vice chairman, and Mrs. Ruby Connell, Chemical Engineering Company, Dallas, secretary-treasurer. The next meeting of the group will be held in Fort Worth the third week in January.

Every

PHOENIX FLANGE

is a precision product

In any drop forging, the product is only as good as the dies. That's why such particular care is taken in their preparation. That's why they're precision made.

A full range of sizes and styles . . . drop forged flanges that stand up under the toughest conditions . . . are available from Phoenix. All are of mild steel readily machined or welded and all meet ASA requirements and ASME and STTM specifications.

Get your copy of the Phoenix Flange Catalog today.

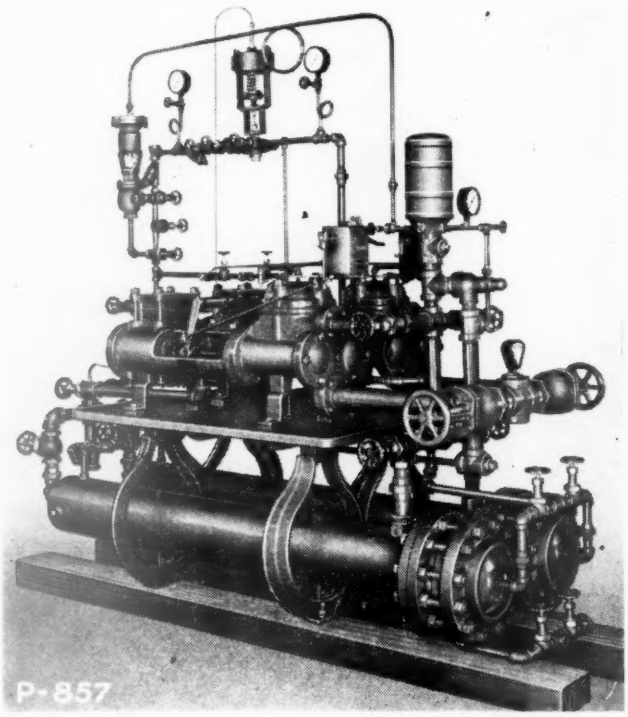
PHOENIX Drop Forged FLANGES

PHOENIX MANUFACTURING COMPANY

Joliet, Illinois — Catasauqua, Pa.

NATIONAL AIROIL FUEL OIL - GAS BURNERS

FUEL OIL PUMPING AND HEATING UNITS



P-857 Model M-2S2H Unit, Size No. 15, Twin Steam Pumps, Size 5¼" x 3½" x 5", Twin Tubular Type Heaters.

...prepare for combustion heavy fuel oil for all types of oil burners

National Airoil Fuel Oil Pumping and Heating Units are especially designed to prepare, for combustion, what is commonly termed No. 6 or Bunker C Fuel Oil. They will draw fuel oil from above ground or underground tanks, preheat it to proper constant temperatures and deliver it to Oil Burners at an even pressure, best suited for the burners. Our Fuel Oil Pumping and Heating Units are the result of years of experience. They come completely equipped ready for steam, exhaust, condensate, oil suction, oil return, and where motor driven pumps are used, electrical connections. All valves, regulators, etc., are readily accessible. The piping arrangement is easily understood. These compact, space-saving units are available in a range of sizes and models in both Medium and High Pressure types. For complete details, write for our Bulletin 40—very interesting and informative.

NATIONAL AIROIL BURNER CO., INC.

Main Offices & Factory: 1259 EAST SEDGLEY AVENUE, PHILADELPHIA 34, PA.
Texas Office 2nd National Bank Bldg., Houston

INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

L. A. Nomads hear football expert

In the absence of Bob Eiche, at Chicago for the API Convention, Los Angeles Nomads monthly meeting, held in the Jonathan Club, November 12, was presided over, and very well too, by Byron Landis. After the usual hour of socializing a goodly gang sat down to dinner, after which as the first business of the evening, Gil Wilson was initiated into regular membership by Jerry Engstrand, and withstood nobly the barrage of innuendo and direct challenge that was hurled at him. It was announced that others elected to associate membership were: Richard Sneddon, Larry Miller, John Regan, Joe C. Brown, Kinzie Miller and Frank Gilstrap.

Nomad Earle Boggess then introduced the feature speaker of the evening, Bob Hall, former University of Southern California All-American football star and track man, who recited some of the outstanding characteristics of the leading football teams of the nation. He also discussed some of the coaching techniques employed by leading college coaches, and predicted the outcome of the coming big games. This dissertation was followed by an interesting motion picture, brought to the meeting by Standard of California, showing the great agricultural and industrial development in the Amazon Valley in South America.

There was again an excellent representation of foreign visitors, and among those introduced by Johnny Mason were N. Youssef, Shell Oil Company, Egypt; Juan D. Pedretti, Union Oil Company, Paraguay; H. C. Carroll, International Petroleum Company, Ltd.; Russell W. Keener, Petro-Tech Service Company; Carl A. Fernandez, Industrial Agencies, Ltd., Trinidad; Marcel Orgeval, SNPLM, France; George Emerick, Socony-Vacuum; Benjamin Sttayne, Socony-Vacuum of Venezuela; Charles R. Wilkinson, Shell Oil Company, Colombia; J. D. Herrenschmidt, SNPLM, France; Ted H. Kopp, Iraq Petroleum Company, Ltd.; Walter L. Sears, Iraq Petroleum,

Top, seated: C. R. Wilkinson, J. D. Herrenschmidt, Ted Kopp, Walter Sears. Standing: R. S. Webb, H. D. Huskey. Bottom, seated: N. Youssef, Juan Pedretti, H. C. Carroll, Russell Keener. Standing: Carl Fernandez, Marcel Orgeval, George Emerick, Ben Sttayne.

Ltd., Dick Reniers, Drilling and Exploration Company; Shih-voo Chow, Chinese Petroleum Company; H. D. Huskey, Iraq Petroleum Company, Ltd.; R. S. Webb, affiliation unknown.

Pyle heads Continental Consolidated

Howard Pyle has resigned his position as vice president of the Bank of America in charge of oil leases, and is now president of the Continental Consolidated Corporation. This organization recently purchased the holdings of Bob New, H. F. Ingold, and the Harwood Foundation in the so-called Continental Companies.

The Continental organizations include Continental, Continental Development, and Continental Northern and Southern corporations. Besides Pyle, directors of Continental Consolidated are Lloyd S. Gilmour of Eastman, Dillon and Company, investment bankers of New York; Milton Linden, vice president of the Continental Companies; G. J. Levingston, and E. C. Simmons. The latter owns all stock in Continental Consolidated Corporation, and is chairman of the board of directors.

Director of Mack research

Appointment of W. E. Day as director of research for Mack Trucks has been announced by W. M. Walworth, vice president and chief engineer of the company. In assuming his new duties Day relinquishes the post of chief metallurgist for Mack, as well as that of general foundry superintendent.

In 1912 Day joined the International Motor Company, now a part of Mack-International Motor Truck Corporation, as a special apprentice. Within a year he was made foreman of the chassis assembly and then foreman over motor assembly, motor test, chassis assembly, and road test. During this period metallurgy began to occupy Day's interest and he took the Sauveur and Boylston course from Harvard, the next year becoming an instructor in the course. Shortly thereafter he set up Mack's first chemical laboratory for checking materials, out of which he eventually evolved the company's present-day chemical and metallurgical laboratories, which are among the best equipped and most elaborate in the automotive industry.

Rogers Lacy, prominent oilman, dies

Rogers E. Lacy, East Texas multimillionaire oilman, died at his home in Longview, Texas, Tuesday, December 9. He was 66 years of age, and had been ill for more than two months.

Early an orphan, Lacy started work on a delivery wagon for 50 cents a day when he left school in the fifth grade. After several lumber mills ended in disasters of nature, he turned to sweet potato farming. On this farm land he got his first oil well. His entry into the oil business was in 1931 when he promoted a one-fourth royalty in the Joiner well of the East Texas field.

At the time of his death his properties included 134 oil wells in East Texas, Mississippi, and Louisiana, and 54 gas wells in East Texas. Among his real estate interests are an asphalt and refining plant at Big Sandy, a cycling plant in Panola County, and a gas distributing system in Longview. His present fortune in oil has been estimated at $45,000,000.

Hill president American Welding Society

The American Welding Society has elected Harold O. Hill as its president for the year 1947-48. Hill assumed that office at the conclusion of the 1947 annual meeting at the Hotel Sherman, Chicago.

Hill is assistant chief engineer, fabricated steel construction, of the Bethlehem Steel Company, at Bethlehem, Pennsylvania. Born in Ontario, Canada, he was educated at the University of Toronto, from which he received the degree of B.A. Sc. in mechanical engineering.

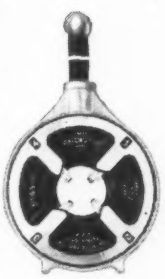
H. O. Hill

He began his engineering career with the Riter-Conley Company of Pittsburgh, Pennsylvania, fabricators of plate and structural steel. Here he served in many capacities and was chief engineer when this company was merged into McClintic-Marshall Company in 1916, when he became assistant chief engineer of the enlarged company in charge of the engineering on tank and platework. When the McClintic-Marshall Company was merged with the Bethlehem Steel Company in 1931 he continued his same duties with the Bethlehem Steel Company.

RIGID No. 65R

10 second adjustment to size instant-setting workholder

● You can't beat the self-contained semi-automatic 65R for speedy get-ready or smooth perfect threads. Its one set of high-speed steel dies adjust to pipe size in 10 seconds. Mistake-proof workholder sets instantly — one screw to tighten, no bushings to bother with. It cuts clean accurate 1" to 2" threads fast, with least work. Durable all-steel-and-malleable. Save time and effort—buy 65R at your Supply House.



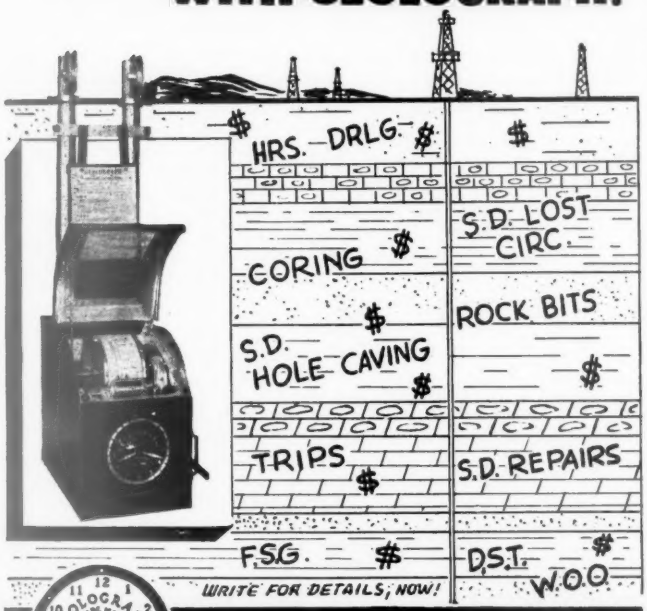
Every 65R must cut a perfect thread before it leaves the factory.

RIGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY • ELYRIA, OHIO

YOU SAVE when you LOG AS YOU DRILL
with GEOLOGRAPH!



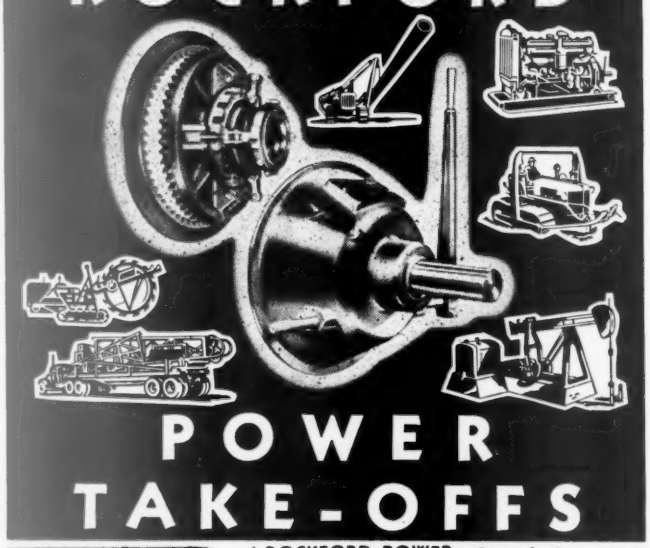
WRITE FOR DETAILS; NOW!

"TIME WILL TELL"

THE GEOLOGRAPH CO. INC.

P. O. Box 1291 Oklahoma City 1, Okla.

ROCKFORD



POWER TAKE-OFFS

SELF CONTAINED UNIT
WIDE RANGE OF SIZES
CONSERVATIVE RATING
ROLLER BEARINGS
FINE ADJUSTMENT
ACCURATE BALANCE
S.A.E. DIMENSIONS

* ROCKFORD POWER TAKE-OFFS are available in standard sizes ranging from 210 foot pounds to 2100 foot pounds torque. Clutch sizes range from 8 to 14 inches double plate. These complete, self-contained units are suitable for heavy-duty gear-tooth application to current industrial gasoline and diesel engines.

Send for This Handy Bulletin

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD CLUTCH DIVISION BORG-WARNER

1303 Eighteenth Avenue, Rockford, Illinois, U.S.A.

Pacific Personalities

DICK SNEDDON

About 20 years ago while we were an inconspicuous resident of Huntington Park, the hub of the Los Angeles industrial district and a mighty convenient spot from which to cover the local oil fields, there used to come sparking Selma, one of the good looking daughters next door, a handsome young blade with a torso like a Roman gladiator, the features of a matinee idol, and thick black wavy hair that made our wife green with envy. Tom was the name of this gallant chap, and we came to know and like him very well. We soon learned that Tom was an oil man; that he was greatly interested in physical culture; and that, believe it or not, he could control his weight within very narrow limits by simply varying the proportion of licorice in his diet. In due time Tom married Selma, and we used to enjoy occasional visits with them, but circumstance (not the police as has been maliciously reported) eventually forced us to move away from Huntington Park, and we sort of lost track of this young couple. So, imagine our surprise to see recently in divers public prints a photograph of this same Tom—Tom McLean, the youngest long service man in the employment of General Petroleum Corporation. At 41 years of age he has already completed 25 years of service with the company, and the light touch of grey that now flecks his copious black thatch doesn't affect his good looks one iota. We wonder, though, if the licorice weight control system still works!

●

We were sitting in with a chummy little group in a Los Angeles hostelry the tother noontime when who should come along, convoyed by that prince of convoyers, Earle Boggess, but Bart Gillespie, honorary member of Nomads, and Henry Nunez, a right sociable toolpusher from down in Guico, Venezuela. Bart was hovering briefly in the City of Los Angeles, visiting a few of his old cronies before returning to his stint at Point Barrow, Alaska, and wayward northern points, and he looked as fit as a college athlete—before the game, that is—despite an already long sojourn on the frozen tundra. Some venturesome soul had the temerity to suggest that he might like to go to the tropics to thaw out before taking off again for the ice and snow, but Bart would most-emphatically have none of it. Robert Service wasn't fooling when he sang the lure of the north country. It really gets a fellow after a while—and it's easy to see that Bart is pretty much in love with this business of slapping icebergs in the face. It's a tough job, all right, but there is a lot of satisfaction in going out there into the wilds and beating the heck out of the elements right in their own back yard. Henry Nunez was on his way back to Venezuela to resume his work with Socony after a two months' leave of absence. He just recently came back from a hunting trip in Canada, during which he bagged a bull moose as big as a pachyderm and had a lot of other fun besides. He left Los Angeles, December 2, and planned to see Joe Louis flatten Jersey Joe Walcott (or vice versa) in New York, before boarding a plane for Guico.

●

In 1945 we joined up with a roistering gang over in Glendale, known as the Optimists perhaps because only an optimist would expect to be heard over the din they made at their 7:30 a.m. Thursday meetings. Anyway, among the members of this distinctly likable group was one highly regarded individual, named "Minsh" for short, who was lauded frequently and long for the fine work he was doing with the local Boy Scouts. We noted that just a few days ago this same Minsh came in for a nice press notice from the Los Angeles Athletic Club *Mercury*, in which he was voted an all-round good fellow and a southpaw squash player of unusual ability. All of which causes us to remember that the squash interest of Francis "Minsh" Minshall, valuation engineer for Continental Oil Company, was inspired by the derring-do of these all-time squash greats—Wendell Jones and Cy Rubel. The battles waged by these two past masters some years ago are still talked about wherever squash fans meet—especially if the fans that meet are Wendell Jones and Cy Rubel.

Because of the encroachment of time, they don't *play* squash any more, they *eat* it, but nonetheless they both have more than the usual share of energy and zip, wherein hangs another tale that we hope to tell some time later.

●

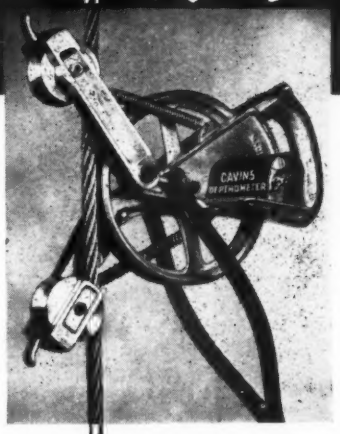
Speaking of sports reminds us that some time agone we hastily gathered together all our scribblings on the subject of golf, submitted them to a publisher, and thereafter sat impatiently waiting for an avalanche of royalties to engulf us. However, there was a heavy frost that year, and the royalty crop was disgustingly low, so we canceled our plans to move to Beverly Hills, and decided to go on wrestling with the oil business. A couple of years ago, Signal Oil and Gas was having its annual divot lifting fiesta, so we gave one of the golf books to Harry Ransford and told him to give it to the winner of the tournament. The other evening at Nomads meeting, John Flanagan casually introduced us to a lad by the name of George Winterburn from Oil Well Supply Company. We noted that the name seemed to recall something awful to him, our name, that is, and it seemed that every time we turned toward the pair unexpectedly, they were exchanging significant glances, and making circular motions with their fingers above their heads. It was difficult to understand all this until we later learned that George had won that Signal golf tournament and had been given the golf book by Harry Ransford. We understand he shoots a neat game down there between 70 and 80, which so far as we are concerned is totally unexplored territory. It turned out interestingly enough that George Winterburn is a brother of Read, who is the local expert on Wilmington sub-strata but a good fellow in spite of that. And just to complete this sequence of coincidences and whatnot, we might remark in passing that if we were a movie scout we would drag this boy Flanagan off to Hollywood even at the risk of making Tyrone Power and some of the other Irishmen mad.

●

Dashed out to the Pacific Lighting compressor station at Santa Fe Springs on November 13 at the invitation of our good friend Otto Mauthe, to take in the formal dedication of the Biggest Inch pipe line. After the ceremony the guests—approximately 200—were entertained, and we mean entertained, in a specially erected marquee where a generous spread of diversified dainties, cooked with Texas gas, kept them nibbling far into the night. We met many erstwhile buddies at this assembly and made the acquaintance of many interesting people. For instance, one of the first persons we spotted reaching for a lamb chop on a stick was the ubiquitous Bob Roberts, a Standard oiler who is as well and favorably known in California as the climate. Following right close on his heels was another popular man about Los Angeles—Gordon Hendry, public relations chief of U. S. Rubber in this vicinity. We had the pleasure of a brief reunion with Bill Moeller, Southern California Gas Company executive, with whom we used to consort some years ago when we were performing as publicity chairman for such CNGA stalwarts as Frick Gibbs and Jess Burk. Bill has always been regarded as one of the best informed men in the natural gas business out thisaway and is a solid citizen into the bargain. He has just one minor fault—plays the ukulele—but claims he has to do it in self defense when Holly Hayter starts playing what he calls music on his guitar.

Also met Tom Bannon, Acme Drilling Company, in fact, we have met Tom so many places lately that we suspect he is trailing us for some detective agency or other. (Once we kept a library book out until it was three days overdue.) Be that as it may we had a pleasant few minutes together, during which Tom introduced his friend, A. Faison Dixon, of Brokaw, Dixon and McKee, the firm that made the estimates of gas reserves for El Paso Natural Gas Company in connection with the planning of the line. Another interesting and interested member of CNGA with whom we exchanged greetings was Bob Tulin, Shell Oil Company's natural gas and gasoline expert, whom we last saw on the Lark going to San Francisco some months ago. Then there was Al Tatkin, petroleum engineer, formerly with McCarty Agency, now with Vapor Recovery Systems, apparently finding the proceedings quite worthwhile and fitting into the scheme like an old timer. Then there were a host of executives —F. S. Wade, president of Southern California Gas Company, who did a thoroughly human job of master-of-ceremonies that contributed in a large way to the success of the event; A. F.

Why Guess ABOUT WIRE LINE MEASUREMENTS?

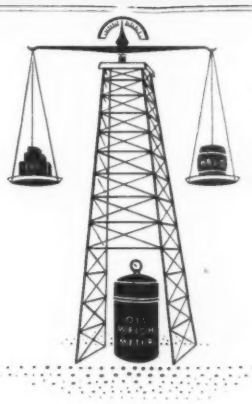


- Easy to Carry
- Direct Reading
- Quickly Put on Line
- Accurate Measurements

The Cavins DEPTHOMETER is a simple, compact, direct-reading device that obsoletes "stringing-in" and gives you accurate measurements in very little more time than it takes to make a trip with your bailer. Comes in a handy carrying case (weighs only 17 pounds)—readily taken to any well—put on the line in a few seconds—priced to pay for itself quickly.—Write for illustrated folder.

THE CAVINS CO.
2853 Cherry Ave., Long Beach 6, California

CAVINS DEPTHOMETER



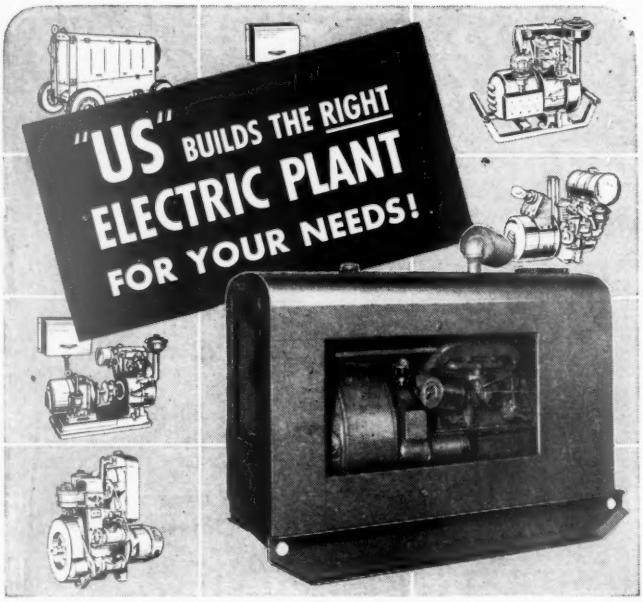
GAUGING BY WEIGHING SOLVES YOUR GAUGING PROBLEMS

Consider a gallon of net oil at base temperature weighing "x" pounds. Increase the temperature and further expand the oil with gas bubbles. The apparent volume is increased but the weight remains the same. The Oil Weigh Meter accurately weighs the oil—cuts a true sample—and effectively separates the oil and gas.

Pats. Pending

Write for descriptive literature

OIL WEIGH METER COMPANY
Since 1929
P. O. Box 366, La Tijera Station
Los Angeles 43, California



"U. S." builds a dependable Electric Plant to fit every oil-field use . . . compact portables for emergency use . . . units in weatherproof housings . . . automatic units for camp lighting. AC and DC units—gasoline, diesel, and for operation on natural gas. Write for information.

US

UNITED STATES MOTORS CORP.
547 Nebraska St. Oshkosh, Wis.

IMPROVED, COLLODIAL LUBRICATED PLASTIC

PACKINGS

for Longer Life

Whether you need one, a hundred or thousands . . . Fel-Pro can supply you . . . and fast. We can furnish packings for practically every purpose, to meet any heat range or resistance condition. Especially suited for oil refineries and similar processes are the Fel-Pro Plastic Packings made of long, soft, high-tensile asbestos fibre impregnated with a blended collodial lubricant that is practically an integral part of the packing. It will withstand exceedingly high temperatures and pressures. Use our expert consultation service to double-check your specifications. We're glad to help solve your packing problems. Write TODAY for Data Bulletin on Fel-Pro Packings, stating your service requirements.

ANTI-FRICTION

SELF-SEALING

HEAT-RESISTANT

NON-HARDENING

PRESSURE-RESISTANT

INDUSTRIAL GASKETS AND PACKING DIVISION OF FELT PRODUCTS MFG. CO., 1535 Carroll Ave., Chicago 7, Ill.

FEL-PRO

for all your PACKING requirements

Bridge, president Southern Counties Gas Company, a clear, convincing speaker; Paul Kyser, president of El Paso Natural Gas Company, a gentleman with a pleasing platform style that made everybody his friend right quickly; Lieutenant Governor Goodwin Knight whose speech was stolen from him in small pieces by six preceding speakers, and did a mighty fine job with the impromptu one he used to take the place of the original. Then there were others, too many to talk about here, some who spoke and some who merely listened, like Hal Price whose minion we once were briefly in Canada and Alaska, and who builds pipe lines when he isn't too busy taking color photographs. What we mean to say is, apologies to those we have missed—and to the principals, congratulations on a swell job, and thanks for a grand time.

●

We note with considerable pleasure that Gus Wetzel of Natural Gas Equipment, Inc., is giving up his inside work, and is being assigned to sales in the Los Angeles area, which carries us back in memory a few years when Gus used to be the Flo Ziegfeld of the CNGA. Many a time we have prowled around behind stage while Gus herded his array of talent out to the footlights. And what talent, whoopee! Sometimes it was so good he had to herd us back to our seat before he could herd it out for the rest of the boys to see. Oh, well, everybody is young once. In the trade press we read that among the employes of Union Oil who have just completed 35 years with the company is Chris Rector. We can remember ten years ago, it seems only yesterday, attending a little party out at Whittier, an unofficial affair given by southern division field employes of their own volition and at their own expense, for Chris on the completion of his 25th year. They gave him a lot of doodads, including a motion picture camera, but we suspect that he got his biggest thrill from the friendly things they told him that day. It was a nice gesture to a nice chap. Another ten years farther back yet, we can recall frequent meetings with Chris and Mrs. Rector at sundry San Joaquin Valley hops, and we not very dainty as we floundered through the occasional square dance in them days, but, by heck, if we do say it ourself, we were certainly vigorous, for such a small guy.

●

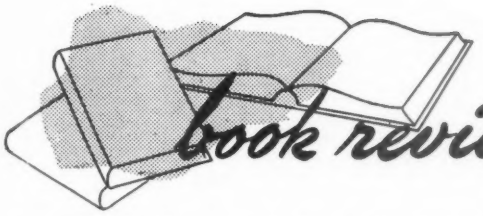
While we are roaming in Union Oil territory, by the way, we spotted recently a brief item on the society page of the *Los Angeles Times* to the effect that "Cyrus Rubel, big time oilman, entertained everyone, believe it or not, by playing on a musical saw!" We are right glad to learn that Cy is not permitting his talent to go to seed. We wonder at the same time if Herb Eggleston, General Petroleum's refinery biggie, is keeping his serrated Amati in good condition. And, Frank Morgan, too—what about the Straddlevarius that once played such an exciting role in the musical development of the California petroleum industry? It was in a sad state of pernicious corrosion when he took it out of the box at Town & Gown Hall some 12 years ago and hammered it into submission. We sincerely hope it hasn't in the meantime disintegrated entirely.

●

And, now, apropos of nothing at all, have you ever noticed the resemblance between Austin Cadle, Standard's manager of economics and statistics, and Howard Hughes? Austin appears to be in better physical shape, but there is certainly a resemblance in the general appearance. We hope, incidentally, it is quite marked in their financial positions. Just back from a four months stay in western Australia are geologists Dr. Mason Hill and Paul Dudley of Richfield Oil Corporation. Leaving almost as we write for Iraq is a large contingent of Californians, including, Charlie LaMar, W. C. Lance, Fred Kopp, Harold Karns, Buck Devine, George Emerick, Walter Sears, J. M. Pickell, and Rex Norton. Also, it is whispered among the derrick groves that Bob Block and Jimmy Dean are going to stay in the homeland indefinitely.

Panhandle district manager

Bethlehem Supply Company announces the recent promotion of H. S. Sutton to manager of the Panhandle district with headquarters at Pampa, Texas. Sutton has been employed by the Bethlehem Supply Company for the last four and one-half years and has been stationed in the Kansas district during his entire service with the company.



● **Secondary Recovery of Oil in the United States, Second Supplement,** *introduction by Paul D. Torrey. American Petroleum Institute, 50 West 50th Street, New York 20. Pages, 215. Price, $2.*

Twenty individual contributions, consisting in the main of papers given at the 1946 API annual meeting in Chicago, make up the body of this supplement on secondary recovery.

Section A concerns itself with the development and operation of secondary recovery projects, while B is composed of related papers dealing with secondary recovery. C section includes the 1943-45 and the 1946 supplements to the secondary recovery bibliography.

● **Drilling and Production Practice, 1946.** *American Petroleum Institute, 50 West 50th Street, New York 20. Pages, 414.*

Papers prepared and presented at national, district, or chapter meetings of the Division of Production during 1946 are presented in a more durable form. The first section contains papers on drilling practice such as directional drilling, deep rotary drilling in the Appalachians, drilling abnormal pressure formations, casing-landing practice, drilling muds, oil-base fluids, and oil-well cementing.

Section two, production practice, discusses well spacing, gas-condensate reservoirs, gas-injection, unitization, repressuring, secondary recovery in California, water-drive, water flooding, and pumping wells with electric power for the optimum rate of production. Materials such as threaded pipe joints leaks, corrosion of high-pressure production equipment, corrosion, and preventive methods, make up part three. Section four contains the miscellaneous papers.

The bibliography has abstracts of all papers presented at district meetings in 1946 and not reproduced in full in this volume.

● **South Texas Oil,** *(in two volumes), by Frank J. Gardner, staff geologist. Rinehart Oil News Company, Tulsa, Oklahoma. Total pages, 400. Price, both volumes complete, $35.*

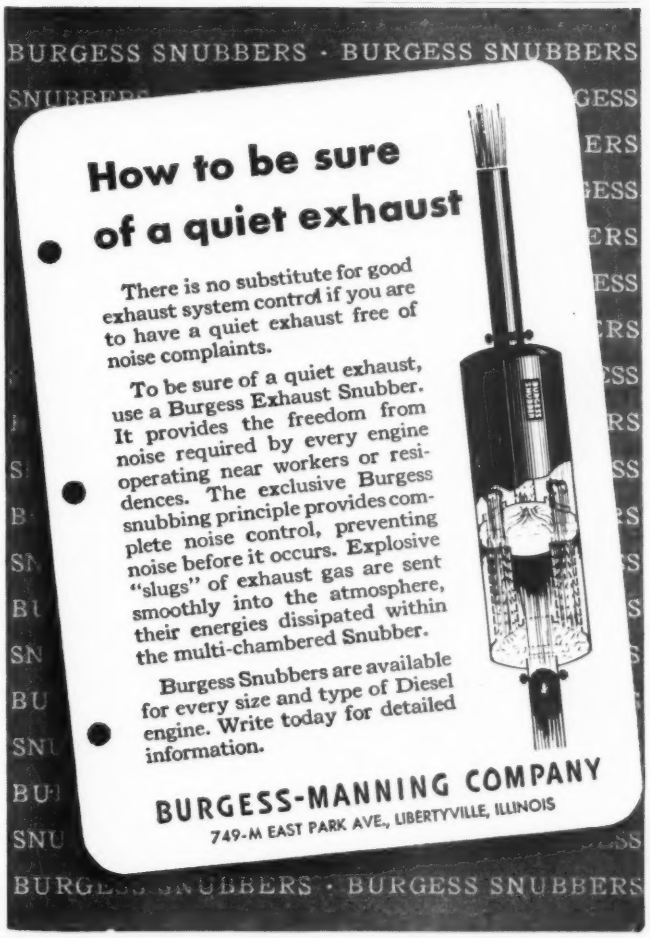
Volume I covers fifteen counties of the Rio Grande embayment. It is a compilation of all available data from many varied sources presented from an unbiased, impartial viewpoint. A historical review takes us back to the Indians using oil gathered from seeps and hand-dug water holes, and brings us to twentieth century development of this area. A thorough study of surface and subsurface structures, with the geological development of fields, gives a clear picture of physical features. Profuse maps and sketches interpret the printed matter.

The general summary of today's oil industry in South Texas includes statistics of production to date, history, bases and methods of proration and conservation, and the method of calculation of gas well allowable. Industrial plants are listed under: Recycling and repressuring plants, natural gasoline plants, carbon black plants and pipe line companies.

The greatest part of the volume is devoted to compilations of individual field data. Field maps of each county aid in fixing location. The discovery well, surface formation, type structure, method of discovery and deepest horizon tested are given. Also included are: Producing horizon, character of oil, number of producing wells, method of proration, daily field allowable, outlets and the yearly production record. Such complete coverage of each field makes this book valuable to men in any division of the oil industry.

Volume II continues the compilation of individual field data on the remaining sixteen counties in South Texas. Since many fields have been known at one time or another by more than one name and others have lost their original identity, a list of field nomenclature equivalents serves as a guide to correct usage. In the final pages there is a bibliography, an addenda, and a complete list of oil and gas fields included in the edition with cumulative production and number of producing wells as of January 1, 1947. A good-sized pull-out oil and gas map of South Texas adds the finishing touch to this regional analysis.

WHAT is YOUR CORROSION PROBLEM ?
HARPER COMPUTER of Corrosion Resistance
THE H. M. HARPER CO.
THE HARPER COMPUTER
of corrosion resistance shows the solution at a glance.
OPERATES LIKE A SLIDE RULE
Lists 142 corrosive conditions and environments.
Shows which of 13 non-ferrous and stainless steel fastenings is best to meet each situation.
Free
TO EXECUTIVES, ENGINEERS AND OTHERS INTERESTED IN NON-CORROSIVE FASTENINGS
WRITE TODAY!
THE H. M. HARPER COMPANY
2675 Fletcher St. Chicago 18, Ill.
Offices in Principal Cities
HARPER
Everlasting Fastenings
Chicago
FASTENINGS OF NON-FERROUS AND STAINLESS STEEL ALLOYS


BURGESS SNUBBERS · BURGESS SNUBBERS
How to be sure of a quiet exhaust
There is no substitute for good exhaust system control if you are to have a quiet exhaust free of noise complaints.
To be sure of a quiet exhaust, use a Burgess Exhaust Snubber. It provides the freedom from noise required by every engine operating near workers or residences. The exclusive Burgess snubbing principle provides complete noise control, preventing noise before it occurs. Explosive "slugs" of exhaust gas are sent smoothly into the atmosphere, their energies dissipated within the multi-chambered Snubber.
Burgess Snubbers are available for every size and type of Diesel engine. Write today for detailed information.
BURGESS-MANNING COMPANY
749-M EAST PARK AVE., LIBERTYVILLE, ILLINOIS
BURGESS SNUBBERS · BURGESS SNUBBERS

ADVERTISERS *index*

A

Allis-Chalmers ... 143
American Cable Division of American Chain & Cable Co., Inc. ... Inside Back Cover
American Car & Foundry Company ... 27
American Chain & Cable Co., Inc. ... Inside Back Cover, 204
American Cyanamid Company, Industrial Chemical Division ... 38
American Iron & Machine Works Co. ... 171
American Manufacturing Co. of Texas ... 2
American Meter Co., Inc. ... 91
American Recording Chart Co. ... 196
American Roller Bearing Co. ... 126, 141
American Sand-Banum Co. ... 216
Armstrong Bros. Tool Co. ... 216
Autoclave Engineers, Inc. ... 177

B

B & W, Inc. ... 219
Baash-Ross Tool Co. ... 183
Babcock & Wilcox Tube Co. ... 202
Baker Oil Tools, Inc. ... 189
Baldwin Locomotive Works ... 173
Baroid Sales Division, National Lead Company ... 109
Bethlehem Supply Company ... 5
Blackmer Pump Company ... 219
Black, Sivalls & Bryson ... 157
Bowser, Inc. ... 194
Brown & Root, Inc. ... 15
Bucyrus-Erie Company ... 65
Burgess-Manning Company ... 229
Byron Jackson Company ... 42

C

Cameron Iron Works, Inc. ... 159
Cardwell Manufacturing Co., Inc. ... 112-113
Cavins Company, The ... 227
Chapman Valve Manufacturing Co. ... 30
Chicago Bridge & Iron Co. ... Inside Front Cover
Classified Advertisements ... 219
Continental Supply Co. ... 170
Cook, C. Lee, Manufacturing Co. ... 23
Core Laboratories, Inc. ... 174
Crane Co. ... 7
Cummins Engine Co. ... 110

D

Dean Bros. Pumps, Inc. ... 186
Detroit Diesel Engine Division, General Motors Corp. ... 71
Dowell Incorporated ... 21
Dresser Industries ... 28, 43
Drilling Specialties Company ... 214

E

Edward Valves, Inc. ... 99

F

Felt Products Mfg. Co. ... 228
Fluor Corporation, Ltd. ... 131
Ford Motor Co. ... 63
Four Wheel Drive Auto Co. ... 29
Foxboro Company, The ... 129
Franks Mfg. Corp. ... 69

G

Gardner-Denver Co. ... 26
Gaso Pump & Burner Mfg. Co. ... 149
General American Transportation Corp., Wiggins Seal Div. ... 103
General Paint Corp. ... 106
Geolograph Co., The ... 226
Graver Tank & Mfg. Co. ... 165
Gray Tool Company ... 61
Griscom-Russell Co. ... 212
Gulf Oil Corporation ... 34

H

Haering, D. W., & Co. ... 176
Halliburton Oil Well Cementing Company ... Back Cover
Happy Company, The ... 6
Harper, H. M., Company ... 229
Hercules Tool Co. ... 154
Hill, Hubbell & Co. Div., General Paint Corp. ... 106
Houston Lighting & Power Company ... 125
Hughes Tool Co. ... 75
Hunt Tool Company ... 145
Hyatt Bearings Div., General Motors Corp. ... 200

I

Ingersoll-Rand Company ... 82
International Harvester Company ... 73
International Petroleum Exposition ... 32

J

Jensen Bros. Mfg. Co. ... 215
Jerguson Gage & Valve Company ... 188
Jones & Laughlin Steel Corp. ... 121
Jones & Laughlin Supply Co. ... 59

K

Kellogg, M. W., Co. ... 84-85
Kobe, Inc. ... 43
Koppers Company, Inc., American Hammered Piston Ring Div. ... 39
Koppers Company, Inc., Bartlett-Hayward Div. ... 107

L

Ladish Company ... 76-77
Lane-Wells Co. ... 166
Larkin Packer Co., Inc. ... 137
Layne & Bowler, Inc. ... 221
Line Scale Co., Inc. ... 219
Link-Belt Co. ... 67
Lone Star Cement Co. ... 13
Lufkin Rule Co. ... 124
Lummus Co. ... 9-10

M

McCullough Tool Company ... 191
Macwhyte Co. ... 3
Magnet Cove Barium Corp. ... 119
Maloney-Crawford Tank & Mfg. Co. ... 139
Mark, Clayton, & Company ... 160
Marsh, Jas. P., Company ... 105
Mayo Hotel ... 219
Mercoid Corporation ... 220
Mission Mfg. Co. ... 147
Moore, Lee C., Corporation ... 179

N

National Airoil Burner Company, Inc. ... 224
National Carbon Company, Inc. ... 25
National Radiator Company, Industrial Division ... 101
National Supply Company ... 123
National Technical Laboratories ... 163
National Tube Co. ... 33
Nelson Electric Manufacturing Co. ... 172
Nordstrom Valve Company ... Front Cover
Norris, W. C., Manufacturing, Inc. ... 1

O

Oakite Products, Inc. ... 192
Oilweigh Meter Company ... 227
Oil Well Supply Company ... 35
Onan, D. W. & Sons, Inc. ... 221
Otis Pressure Control, Inc. ... 81

P

Pacific Pumps, Inc. ... 28
Parkersburg Rig & Reel Co., The ... 117
Patterson-Ballagh Division of Byron Jackson Company ... 127, 215
Peerless Pump Div., Food Machinery Corp. ... 184
Penberthy Injector Co. ... 19
Petroleum Data Book, The ... 41
Petroleum Electric Power Association ... 181
Petroleum Rectifying Co. ... 169
Phoenix Manufacturing Co. ... 223
Pittsburgh Equitable Meter Co. ... 97
Powell, Wm., Co. ... 217
Precision Scientific Company ... 87

R

Reading-Pratt & Cady Div., American Chain & Cable Co., Inc. ... 204
Reed Roller Bit Co. ... 46
Refinery Supply Co. ... 218
Regan Forge & Engineering Co. ... 182
Republic Steel Corp. ... 44
Ridge Tool Co. ... 4, 225
Rockford Clutch Div. ... 226
Roebling's, John A., Sons Co. ... 185

S

Schlumberger Well Surveying Corp. ... 135
Shaffer Tool Works ... 187
Spang & Company ... 156
Standard Oil Co. of Calif. ... 11
Stewart & Stevenson Services ... 31
Sun Shipbuilding & Dry Dock Co. ... 133

T

Taylor, S. G., Chain Co. ... 193
Thermoid Co. ... 195
Toledo Pipe Threading Machine Co. ... 208
Tretolite Company ... 115
Twin Disc Clutch Co. ... 45

U

Unit Rig & Equipment Co. ... 198
United States Motors Corp. ... 228
United States Steel Corporation ... 33, 35
United Supply & Manufacturing Co. ... 151
Visco Products Co., Inc. ... 206

V

Vogt, Henry, Machine Co. ... 197

W

Waldrip Engineering Company ... 210
Watson-Stillman Co. ... 93
Wedge Protectors, Inc. ... 104
Whitney Chain & Mfg. Co., The ... 78
Wickwire Spencer Steel Co. ... 40
Wilson Supply Company ... 155
Wilson, K. R. ... 153
Wisconsin Motor Corporation ... 220
Worthington Pump & Machinery Corp. ... 36, 95
Wyatt Metal & Boiler Works ... 89

Y

Young Radiator Co. ... 222
Youngstown Sheet & Tube Co. ... 37